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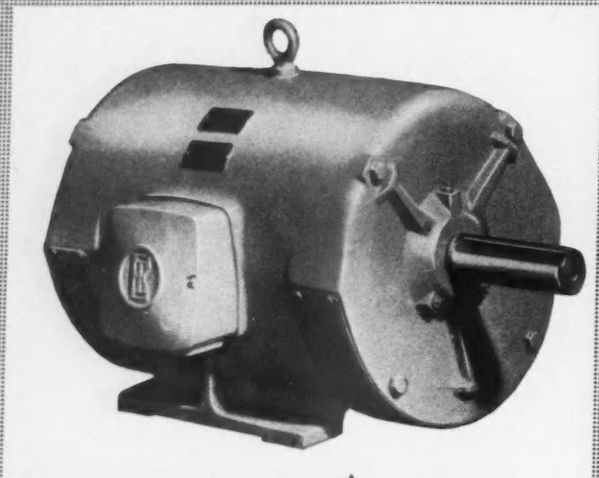

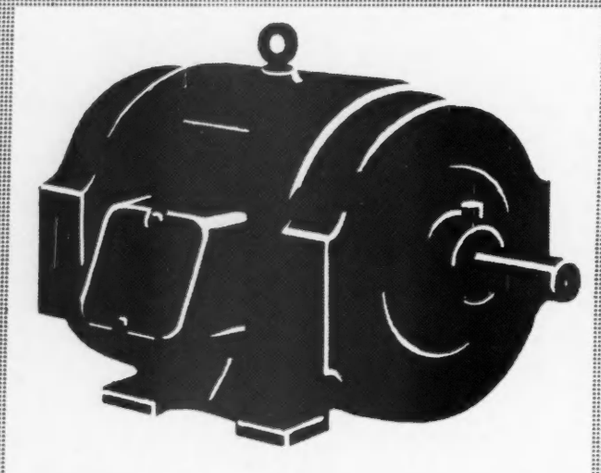

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No. 5325 **FEBRUARY 14, 1958** **VOL. 205**

EDITORIAL CONTENTS

Leading Articles

" Mechanicals " Midsummer Madness 231
Clean Air Act 232
Teachers for Technical Colleges 232
Insurance Against Nuclear Accidents 233
Admiralty Reorganisation 233

Articles

100 Years Ago 233
W. A. Tuplin Cost and Value of Automatic Train Control 234
Professor A. D. Baxter Satellite Rocket Problems 236
Tobias and Fishwick Theory of Regenerative Machine Tool Chatter. No. II 238
University Scholarships 239
Joe T. Richardson Measuring the Structural Behaviour of Hungry Horse Dam 240
J. Howlett Digital Computers and the Design of Nuclear Reactors 243
E. C. Poultney Locomotive Performance 245
Wood Chip Drying Plant 252
J. H. Sainsbury Air Suspension for Road Vehicles No. I 253
New Tunnels at Hadley Wood and Potters Bar 254
High Polymers and their Physical Behaviour 256
550MW Boiler for Thorpe Marsh Power Station 256
Capacitance-Operated Level Controller 256
Single Geared Rubber Mill 257
Road Tanker Construction 257
Electrodes for Gouging and Piercing 258
Ten-Speed Transmission 258
Air Cleaning 258
Welding Gun 258

Continental Section

Open-Hearth Plant of August Thyssen-Hütte. First Brazilian Oxygen Steel Works . 260
Berlin Congress Hall. Professor Ernst Heinkel. ECSC Housing Progress 261
Association of German Engineers in 1956. Federation of French Industries. European Organisation for Nuclear Research. Belgian Electrical Equipment for Finland. . . 262

American Section

American Satellite 263
Detroit in 1958. Modification of Basis for Radiation Dose Calibration. 264
New Magnetic Memory Concept. U.S.-German Nuclear Energy Firm. 265

LETTERS Composite Steel and Concrete Construction 250

BOOK REVIEWS 250

NEWS AND NOTES Industrial and Labour Notes 259
Personal and Business. British Patent Specifications. Forthcoming Engagements. 266–268
Technical Reports 251
British Standards Institution 249

INDEX TO ADVERTISERS : PAGE 141 **CLASSIFIED ADVERTISEMENTS : PAGE 132**

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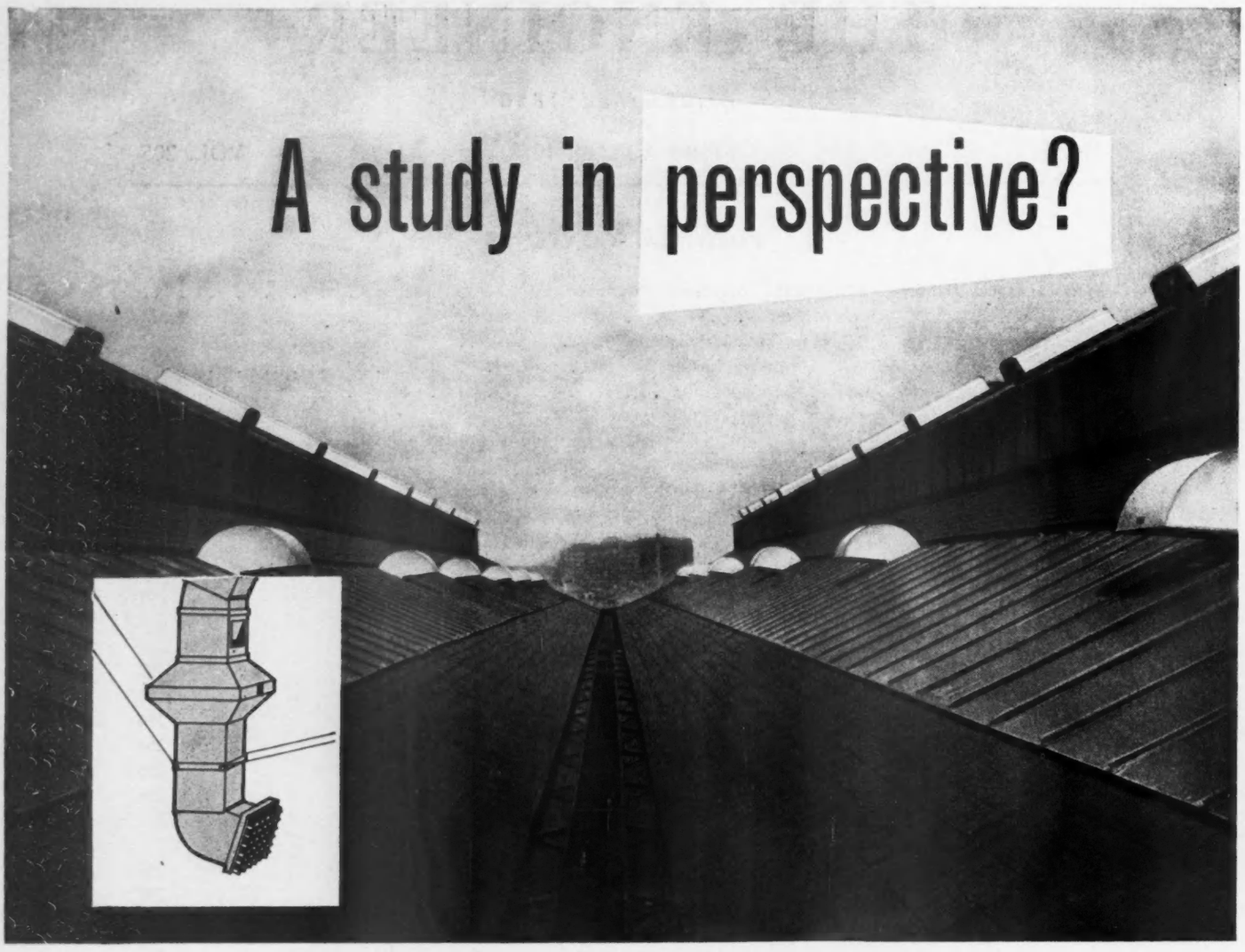

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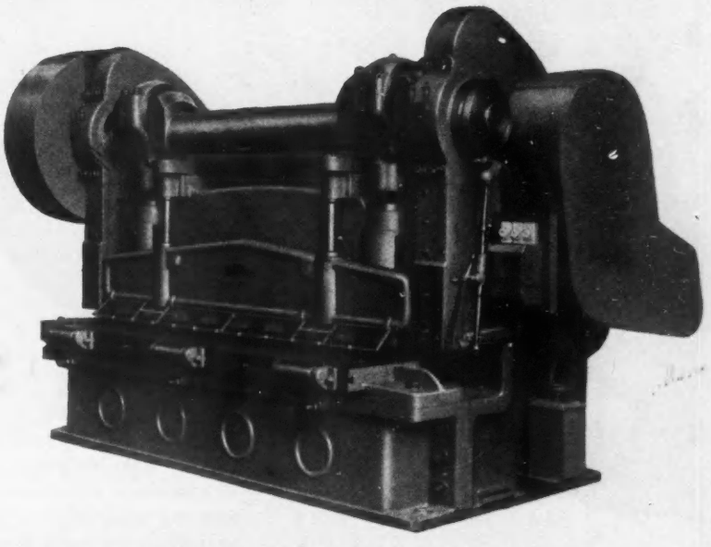

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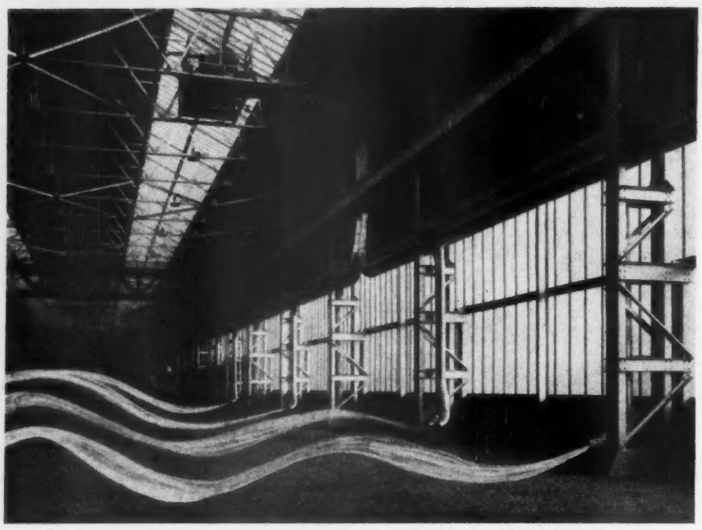

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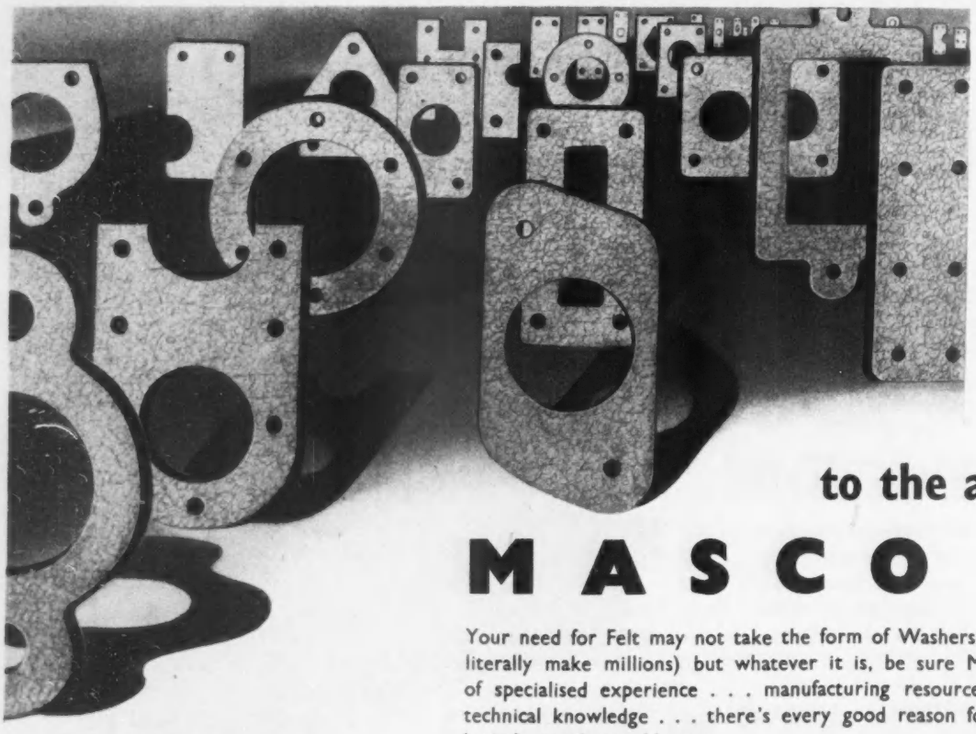

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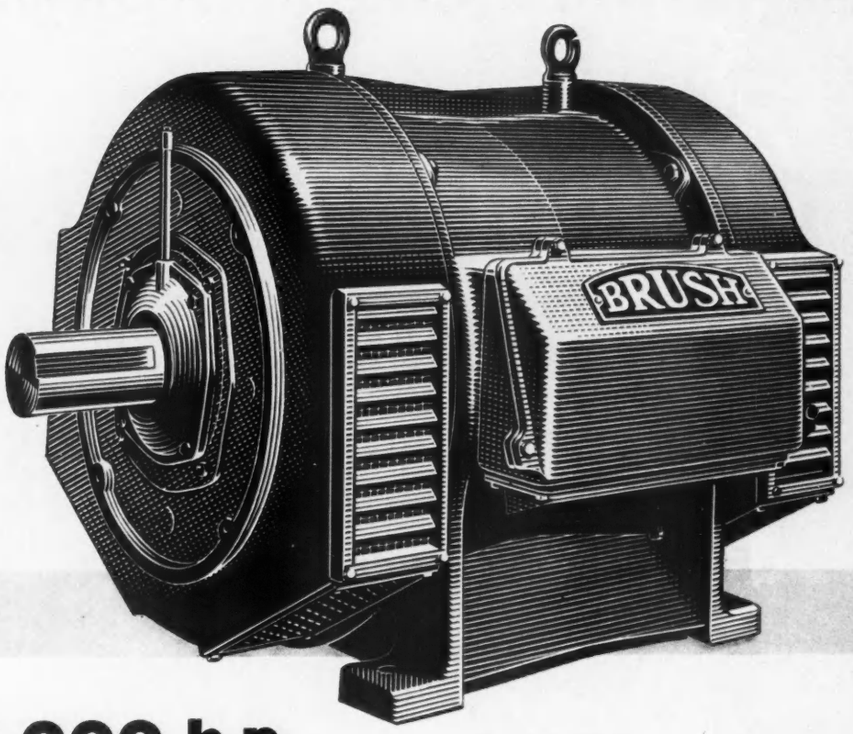

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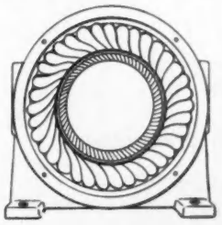

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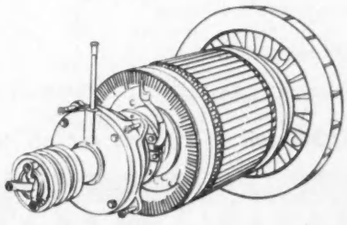

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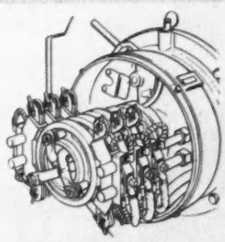

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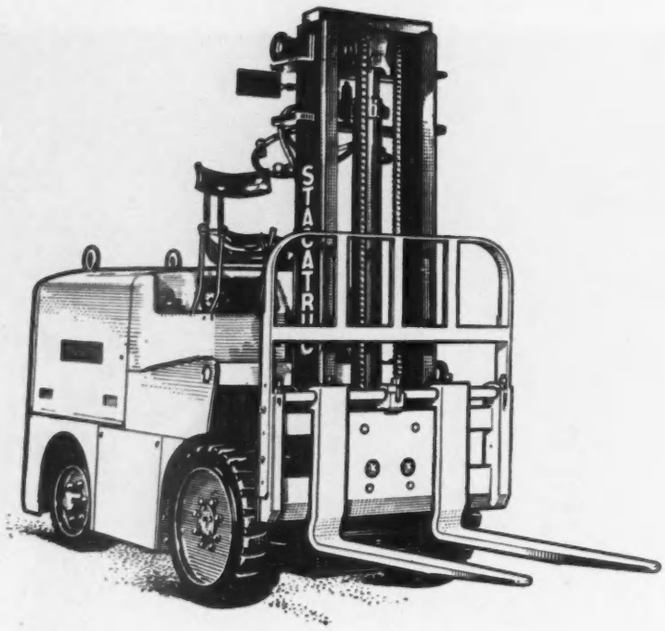

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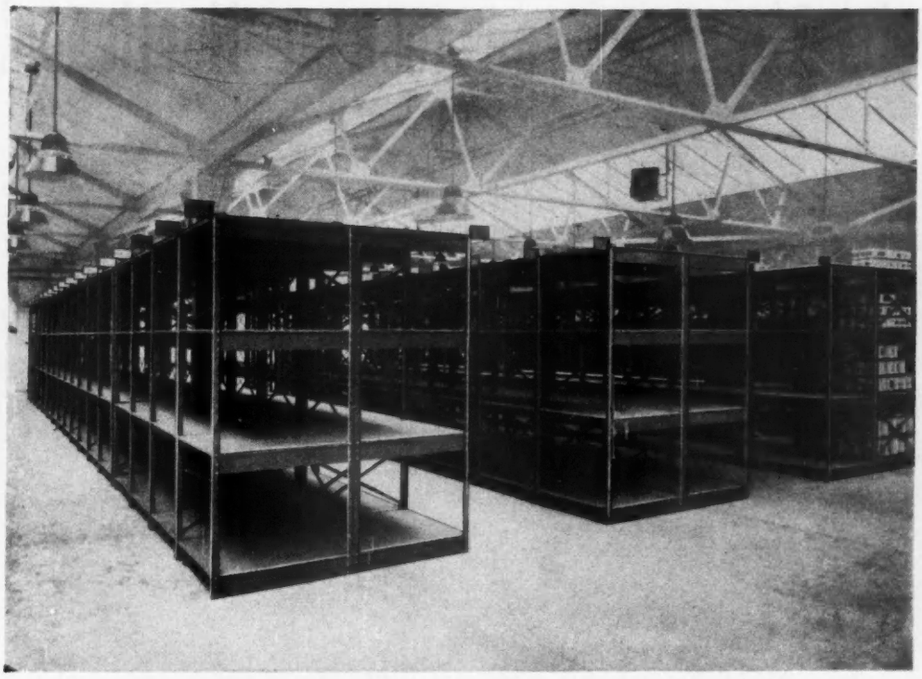

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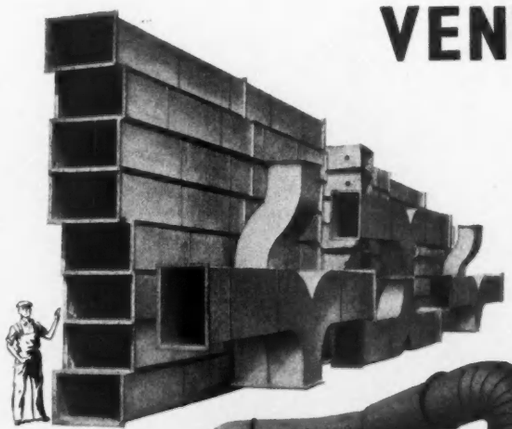

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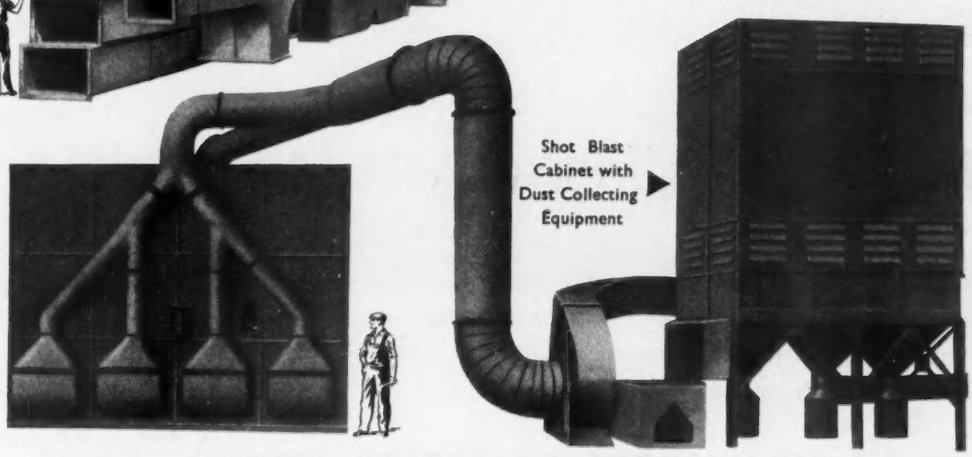

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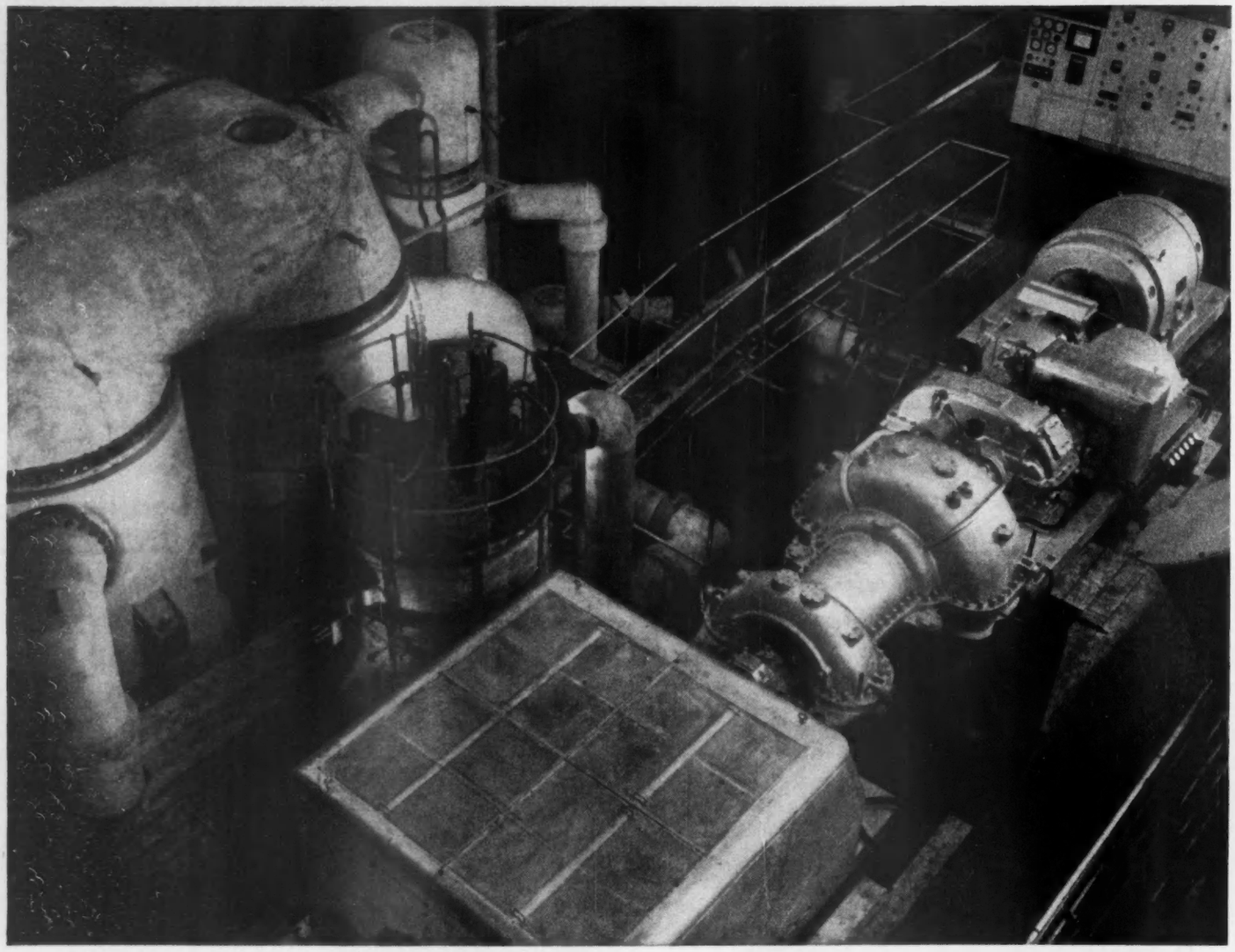

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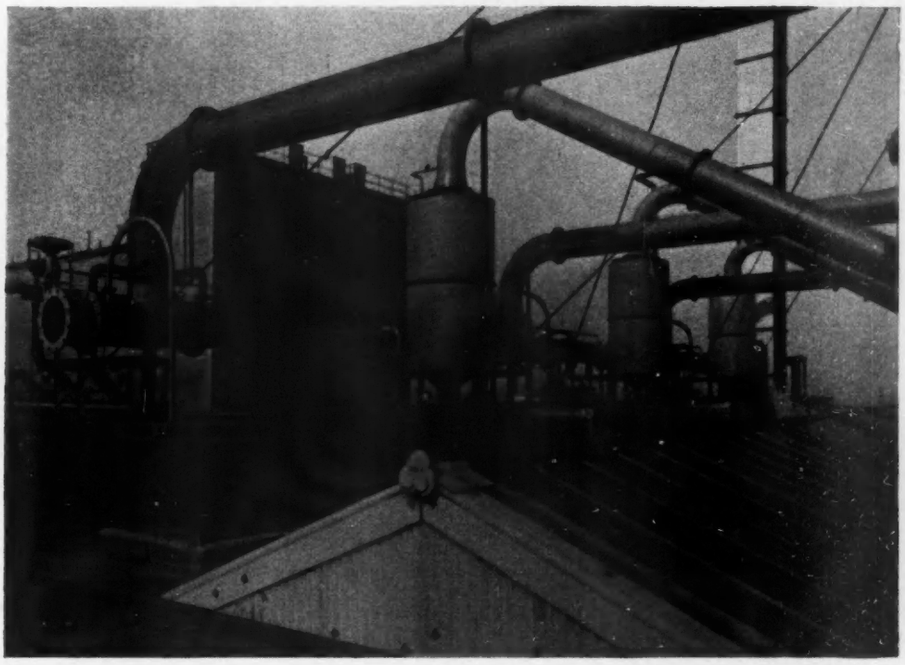

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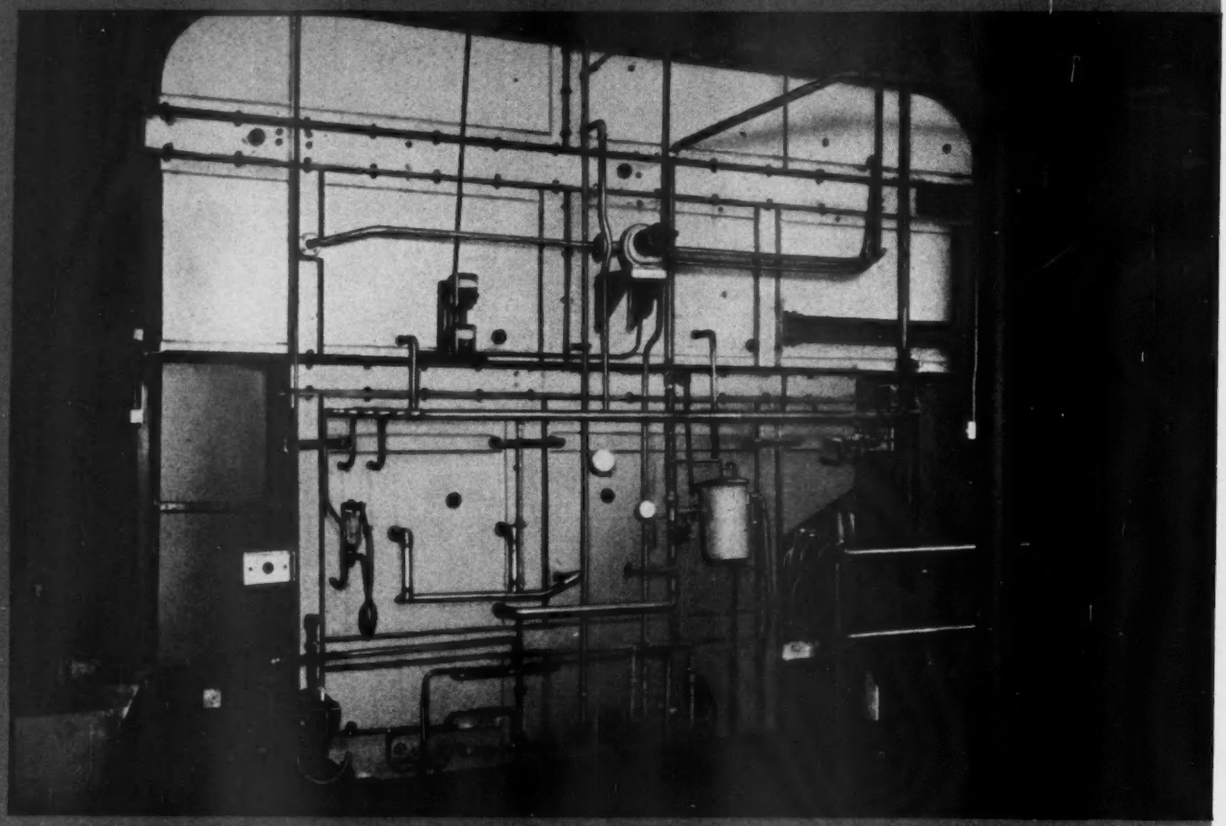
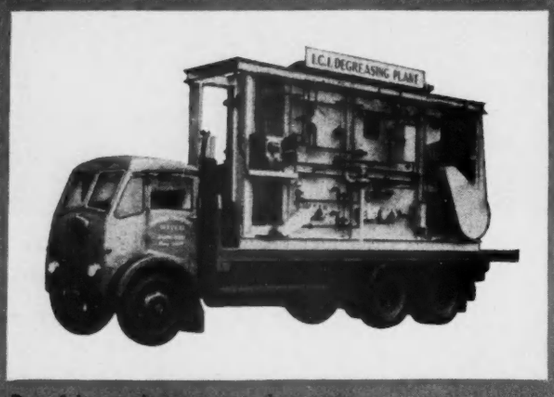


The original plant in service.

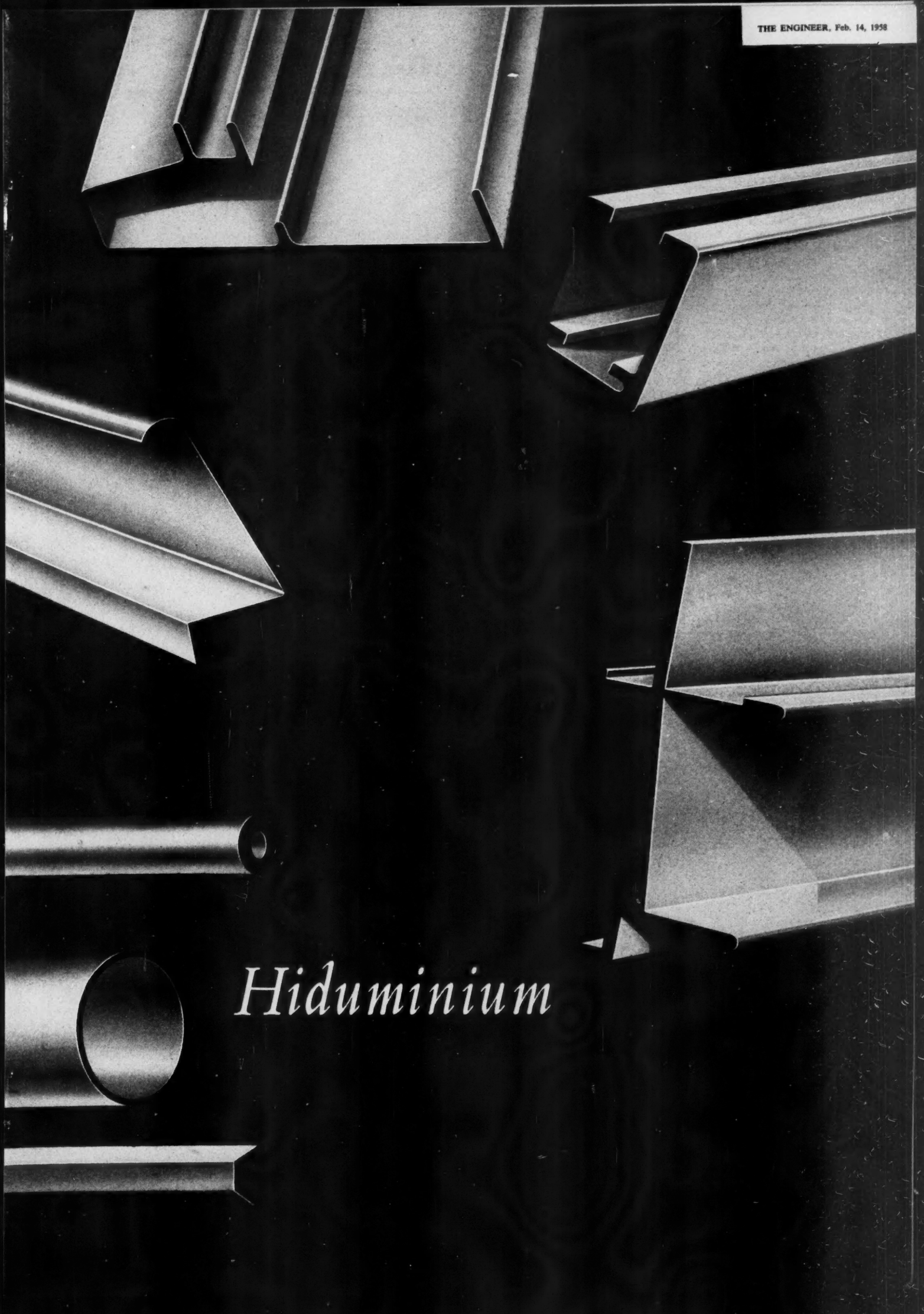
1957 In connection with extensions to their factory, Raleigh Industries Ltd. ordered a second plant, designed to deal with 200 tons of cycle parts during a working week of 100 hours. Apart from increased capacity and some minor modifications, this plant is similar to the first one.

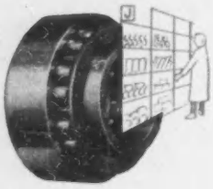


Part of the new plant en route to the customer.

ICI **Imperial Chemical Industries Ltd., London, S.W.1**

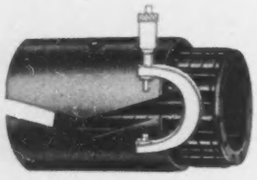
DP295


Hiduminium



It means that a large standard range of roller bearings, in different types and sizes, is available, together with expert advice as to the most suitable bearing for any particular application.

It means that laboratory tests and reports ensure perfection in production and highest efficiency in operation. No problem is too large or small for the Salter R.B. Research Department.



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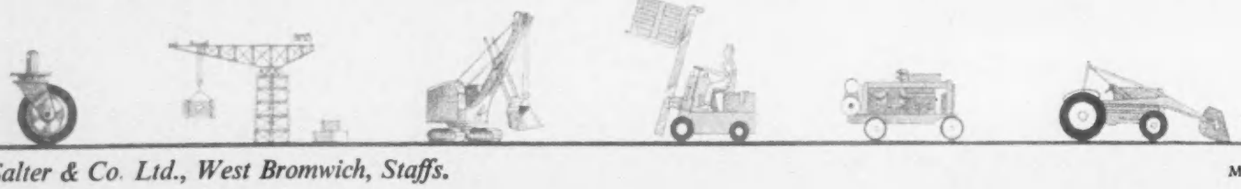

Geo. Salter & Co. Ltd., West Bromwich, Staffs.

M-W.413

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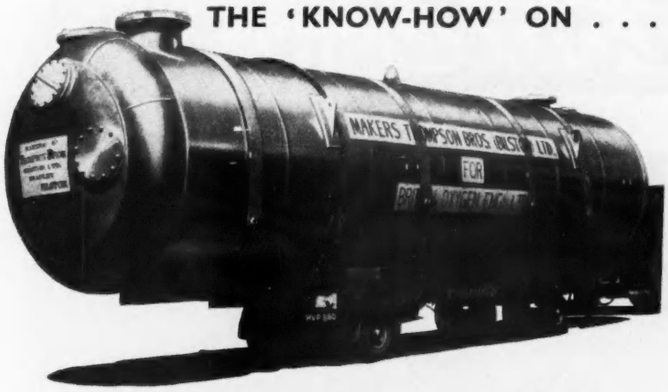
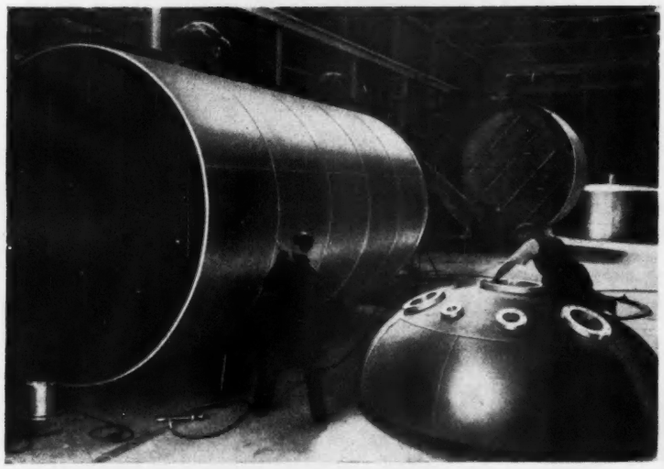
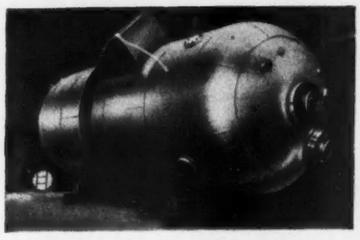


ALUMINIUM



FABRICATION



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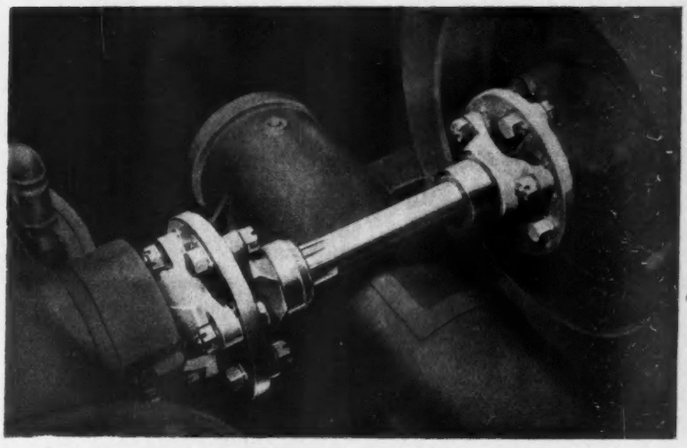

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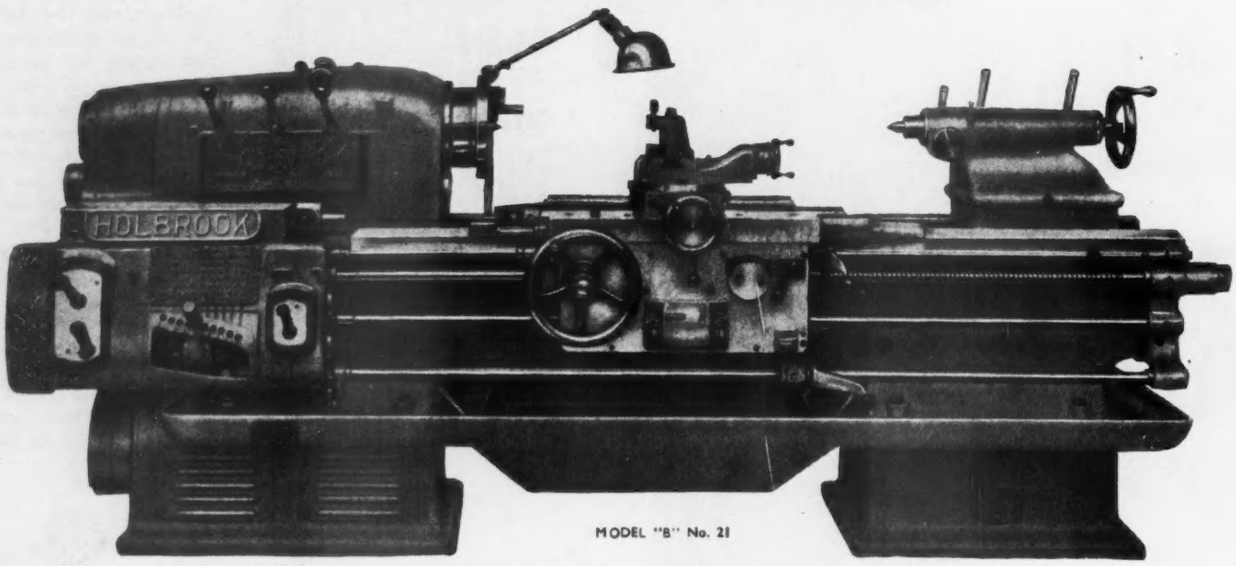

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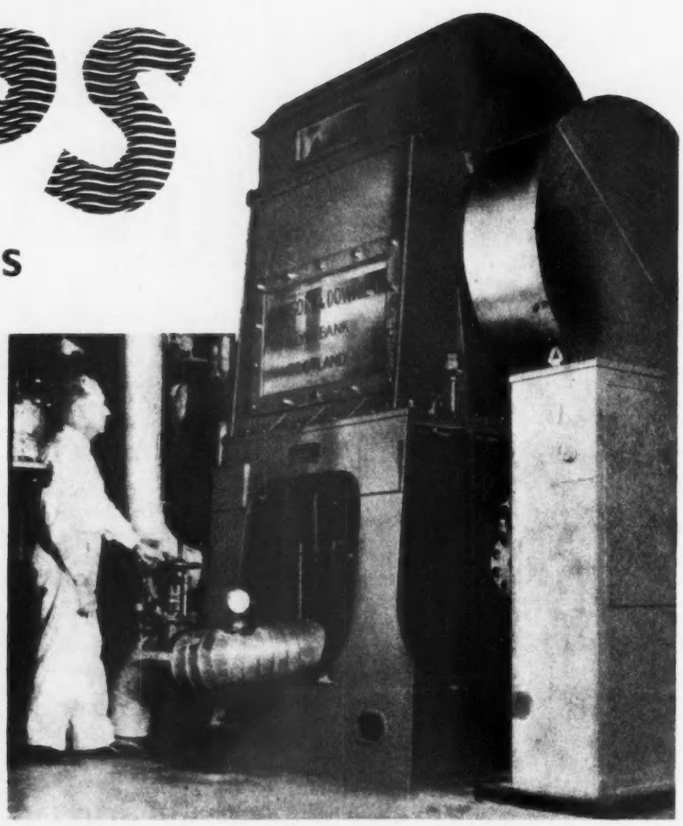

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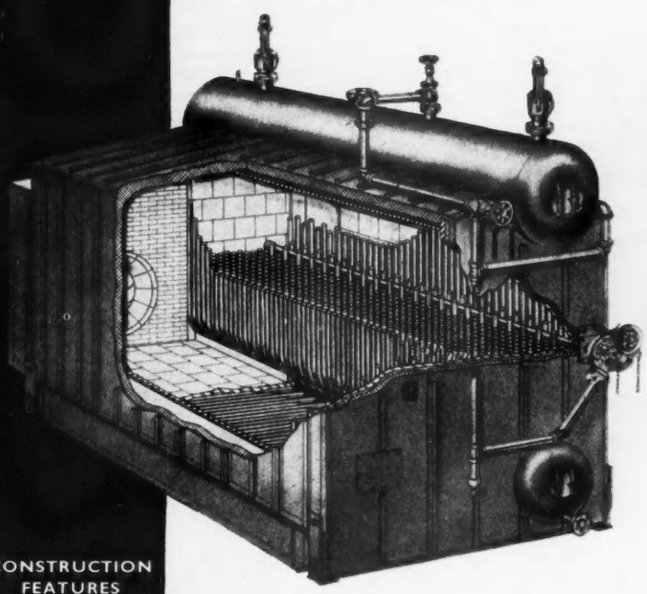

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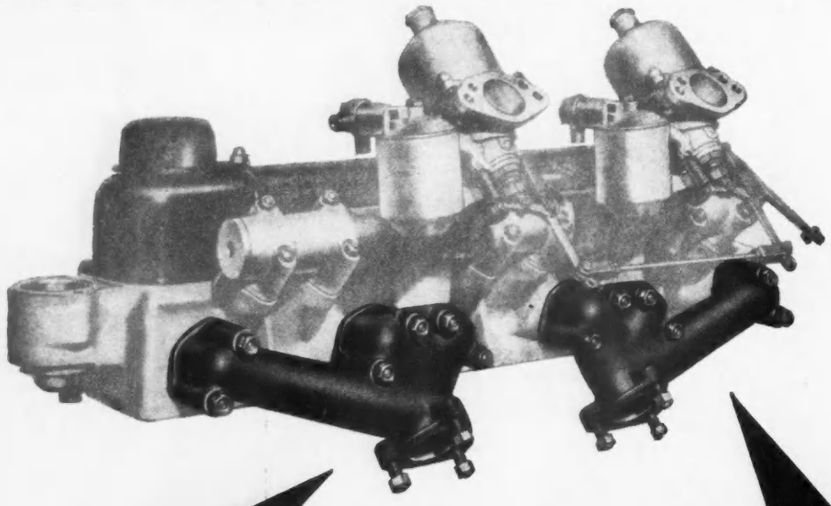

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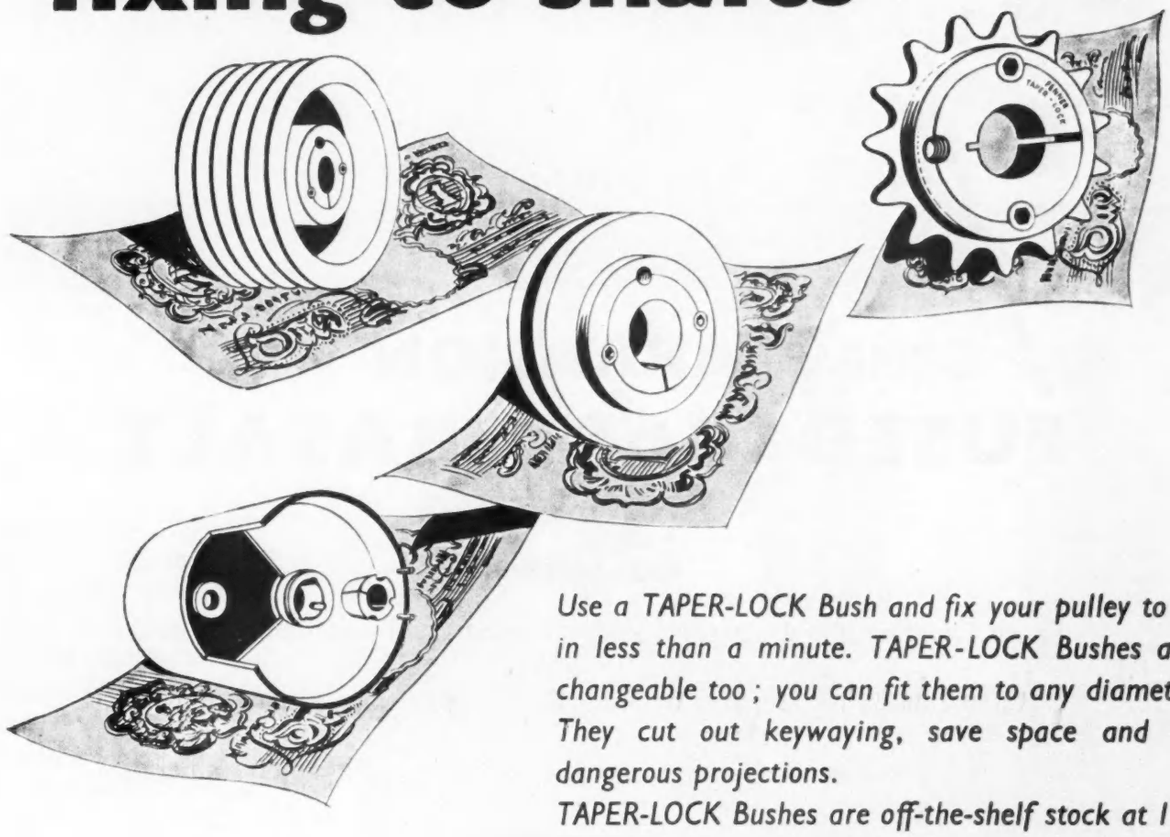

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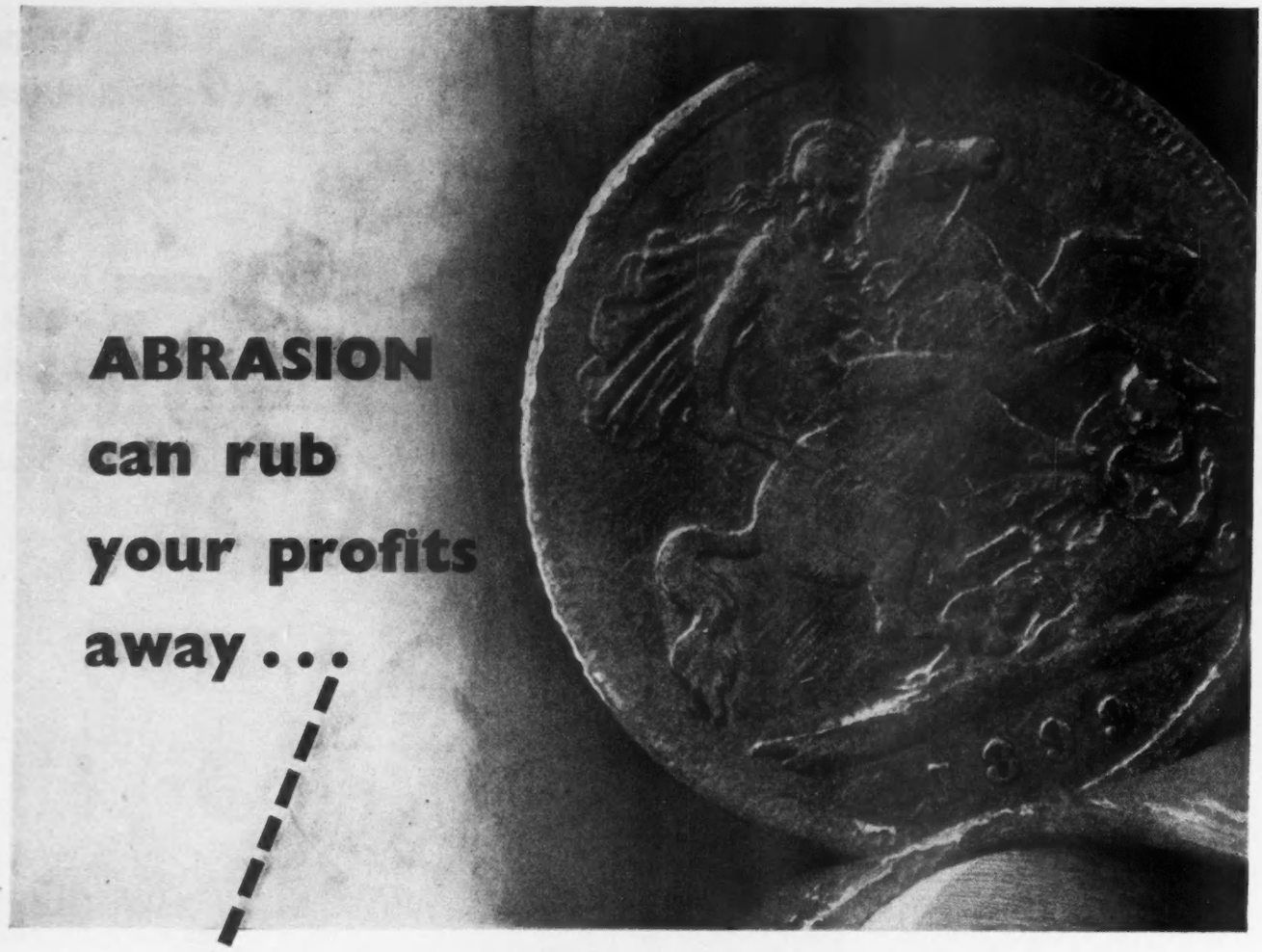

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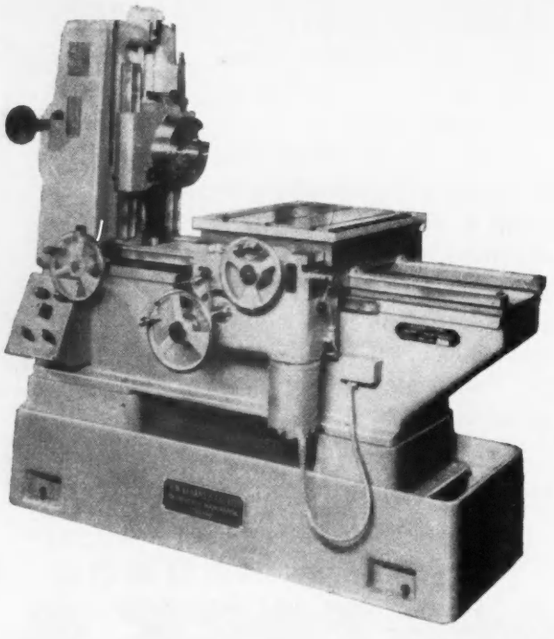

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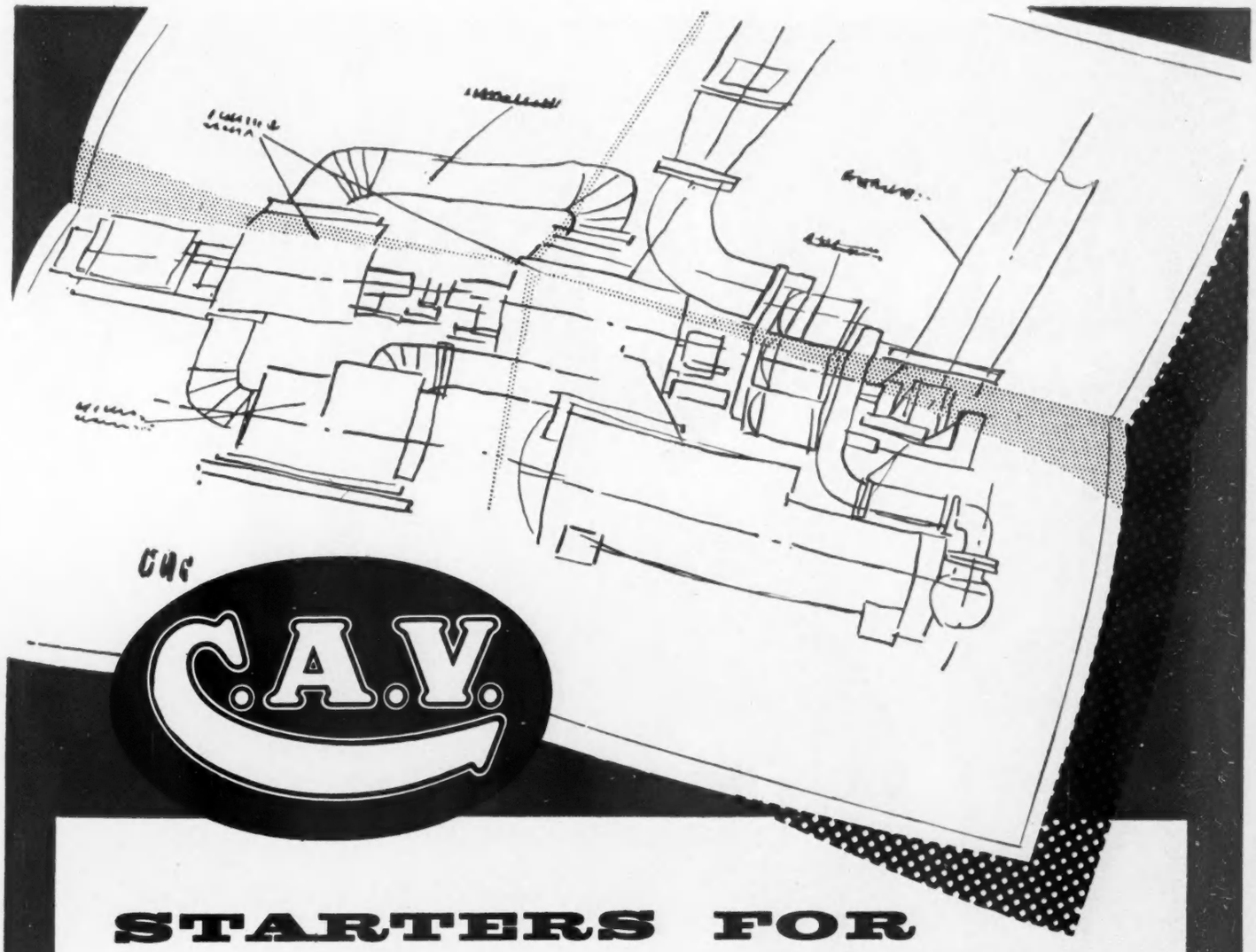

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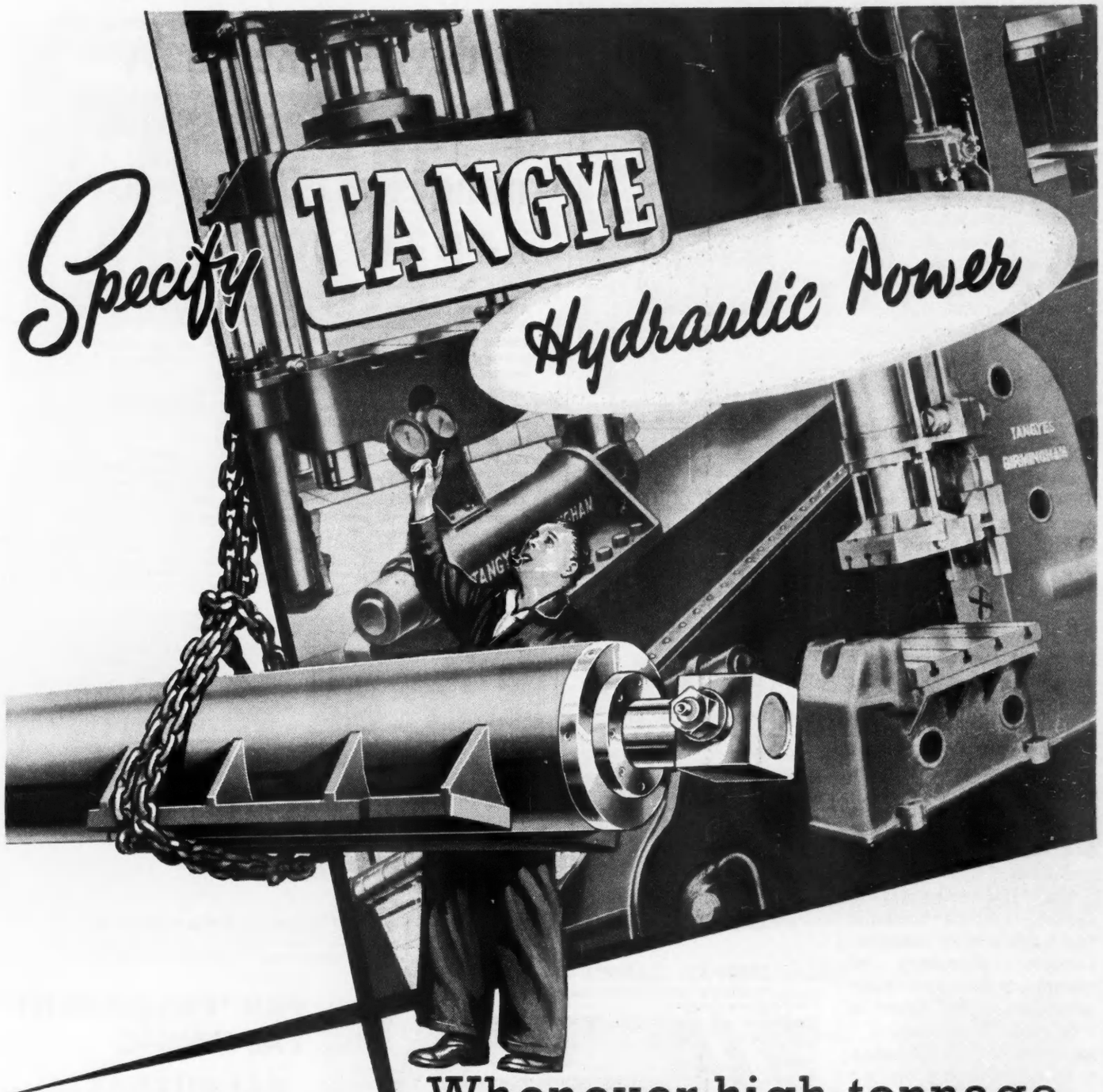

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AID spray equipment will apply your finishes or coatings faster, easier and better. Now that's quite a bold claim to make, but having wrestled with the problem of applying practically every imaginable type of fluid to so many surfaces for so many years, we know that our practical experience will give you better finishes in shorter time with resultant economy.

AID equipment, from guns, through compressors and to complete installations, is the result of shirt-sleeve knowledge acquired where it matters most — in the workshop.

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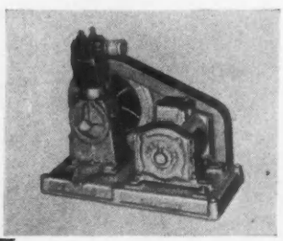
Model 10/14B. *Single stage semi-automatic stationary compressor — supplied complete with air receiver*



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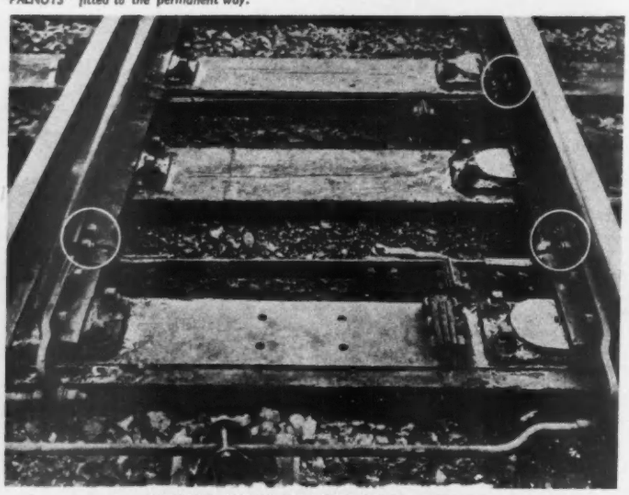

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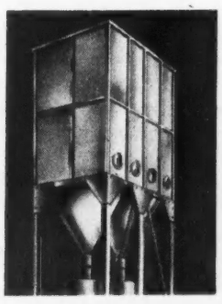

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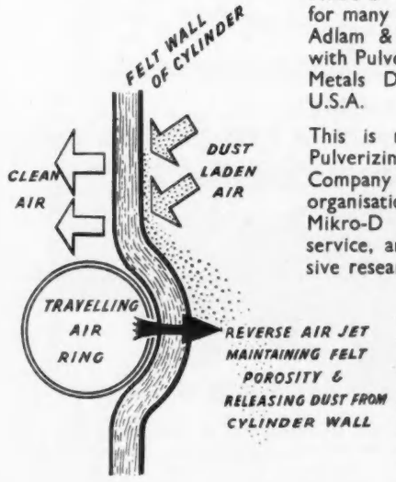
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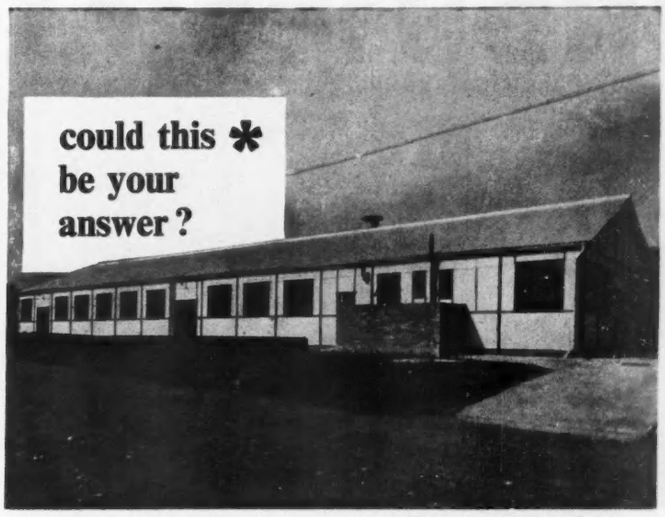

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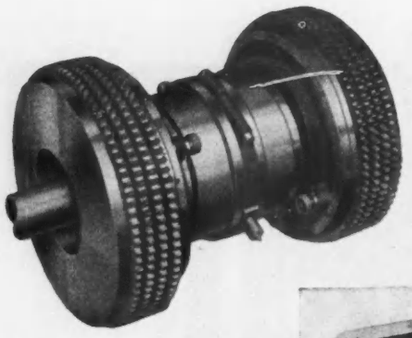

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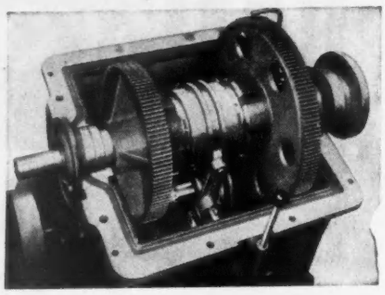

The illustrations show a typical application. The Reid Gear Co., Ltd., required a powerful, sensitive and completely trustworthy clutch unit for their two-speed reduction gear, to transmit the enormous effort applied in actuating the emergency sluice gate on a Scottish Hydro-Electric Project. The features mentioned above qualify Taylor Clutches to satisfy such exacting demands because they constitute the very ingredients of strength and reliability—the choice was a Taylor Multiple Disc Clutch.

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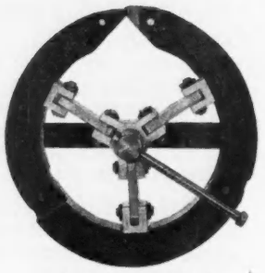

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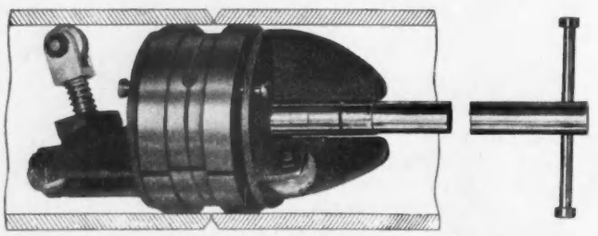

The aligner, in the contracted position, is propelled along the pipe internally in a position between the pipes to be butt welded. By operating a tommy bar on the end of extension tubes the aligner is expanded and presses out the pipe walls to their truly round form. Pressure holds the two pipes together in perfect alignment whilst the weld is laid—the aligner is then contracted and rolled along the pipe for the next weld.

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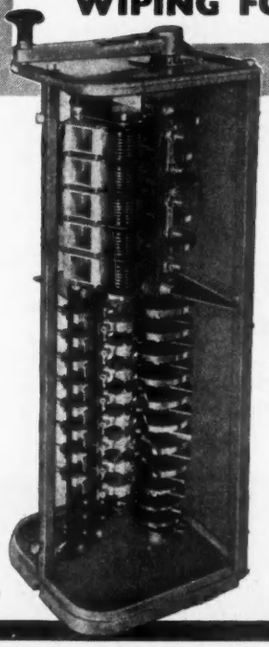

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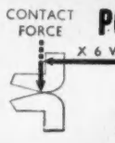

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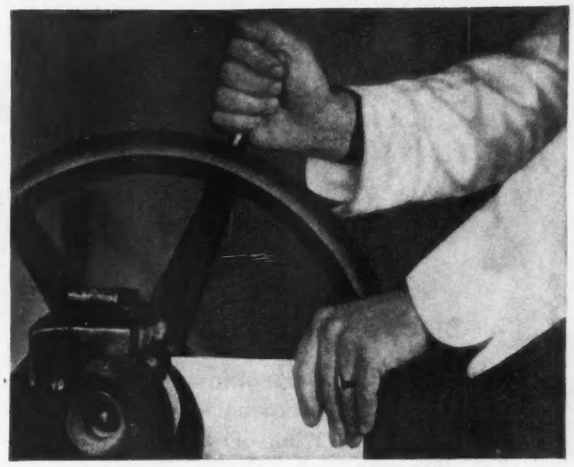

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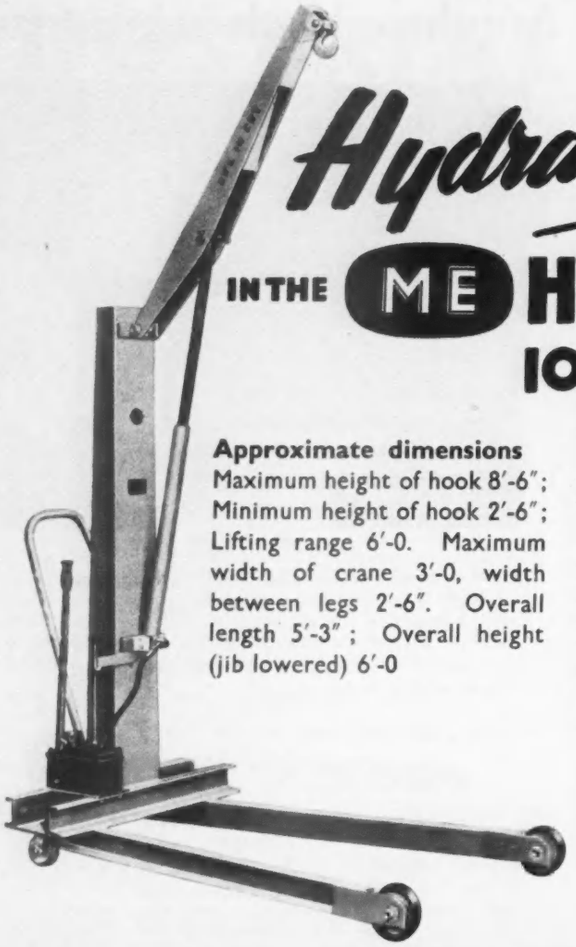

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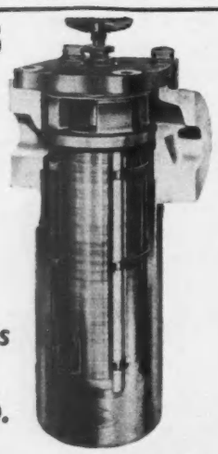

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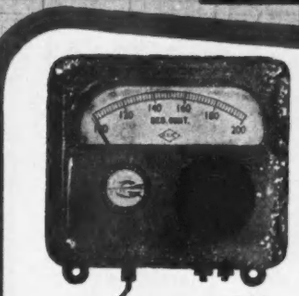

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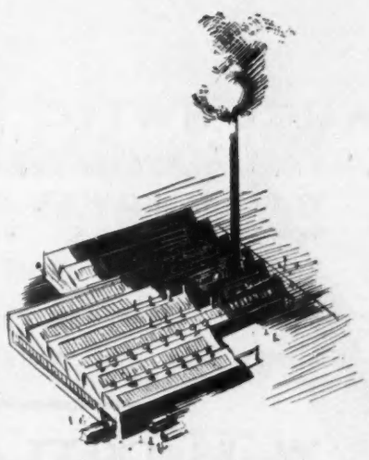

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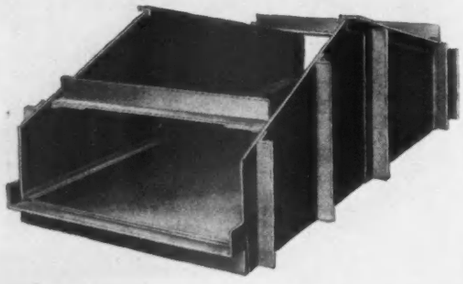

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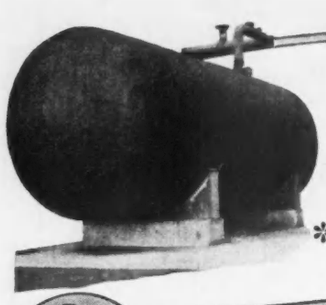

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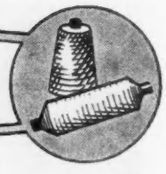

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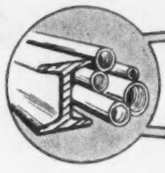

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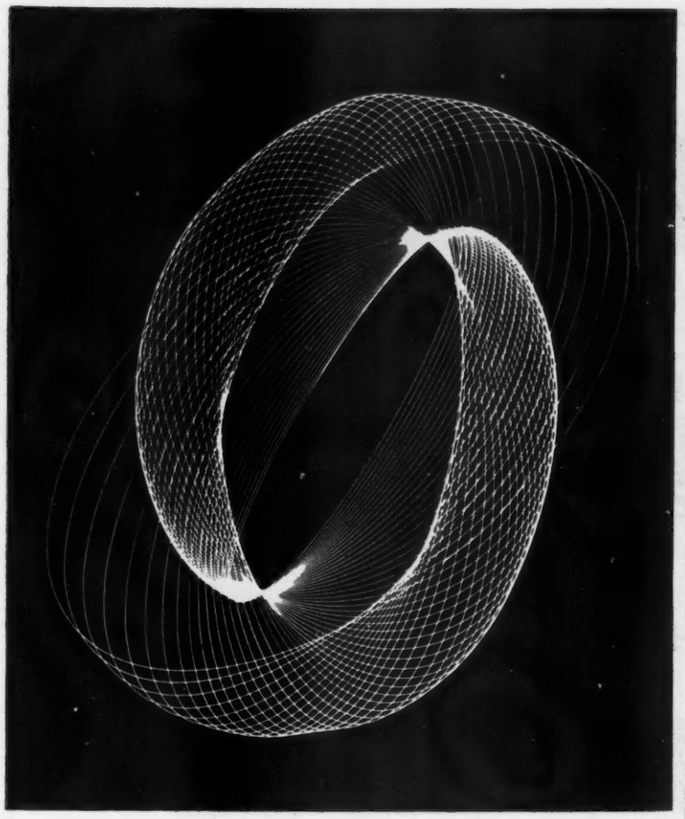

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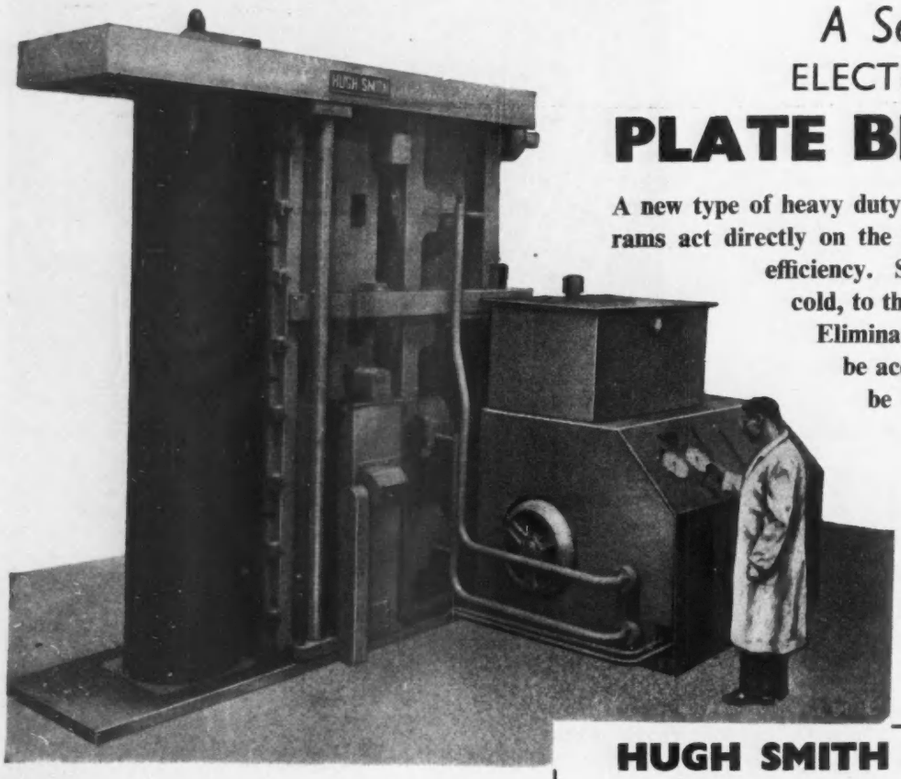

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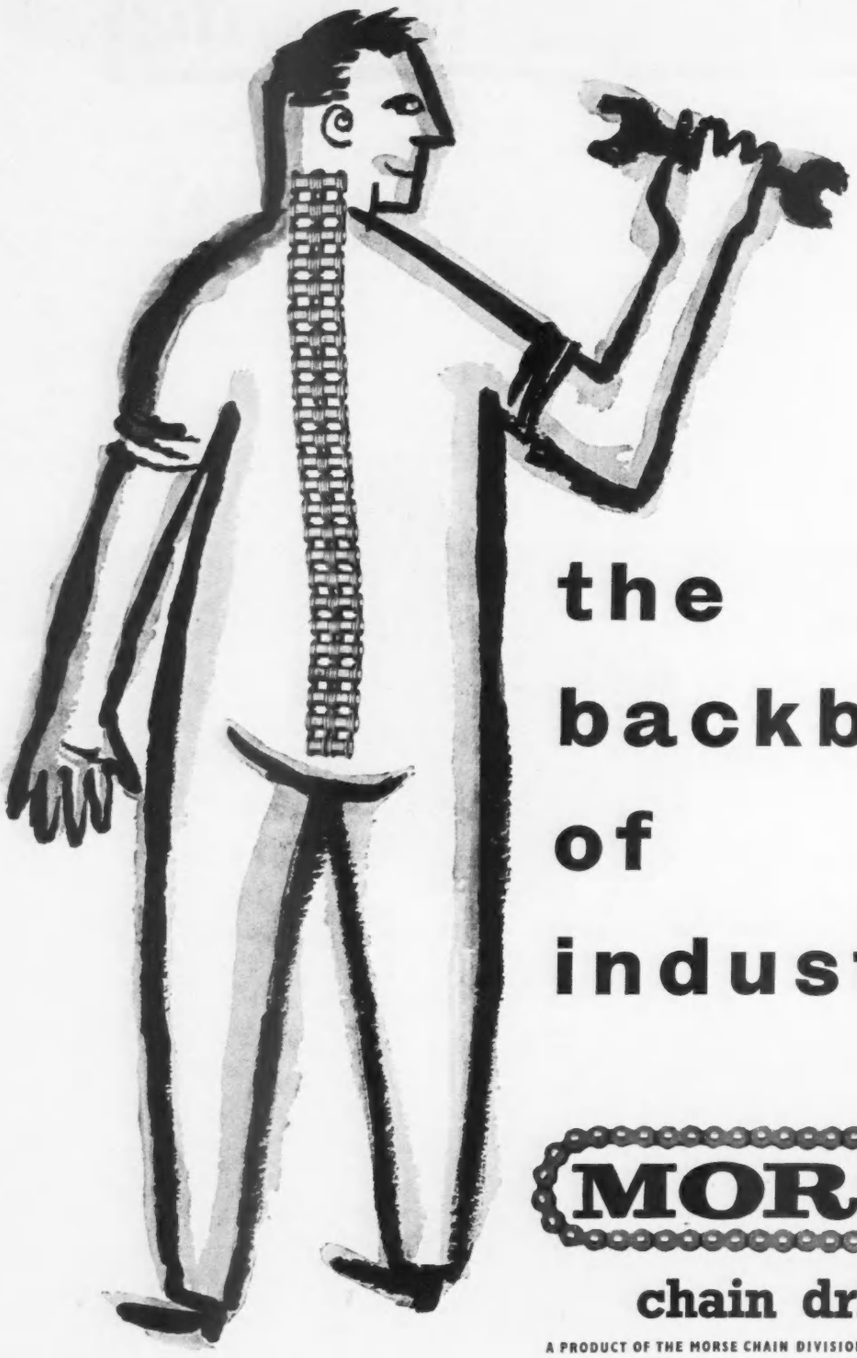

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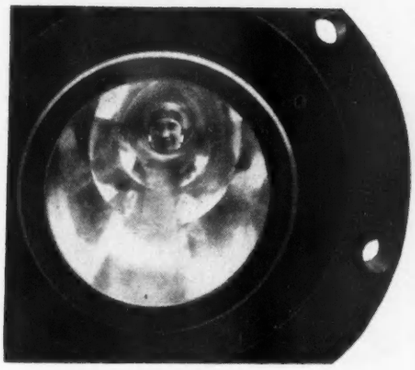

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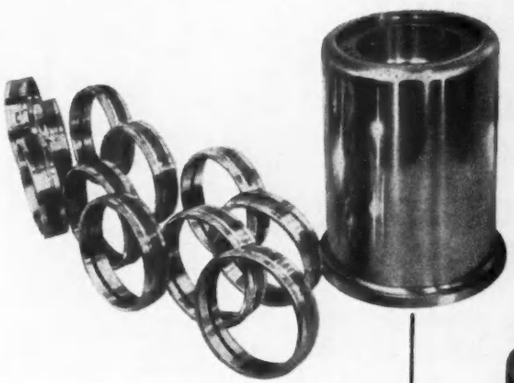

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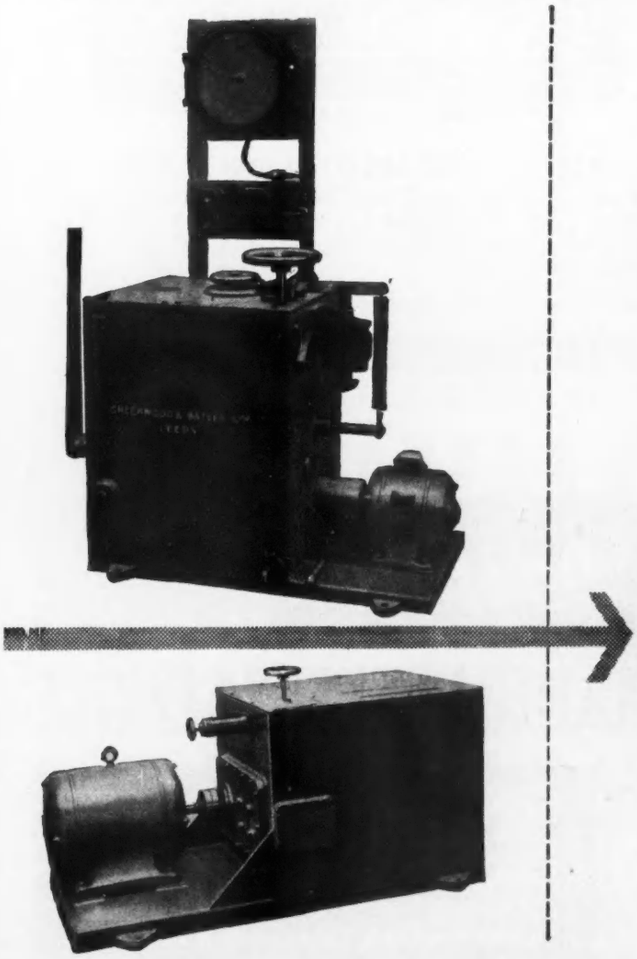

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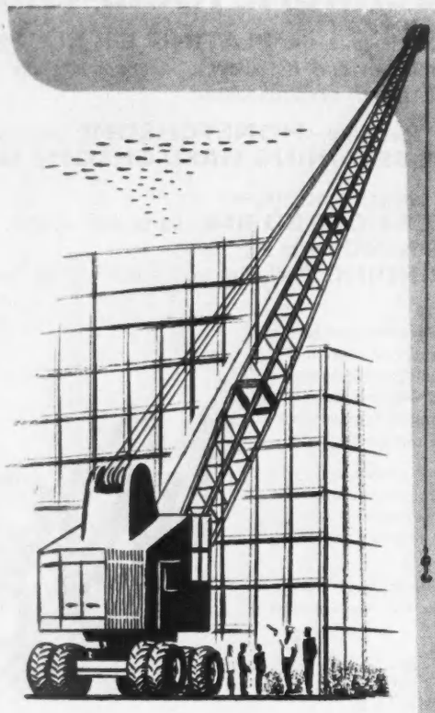

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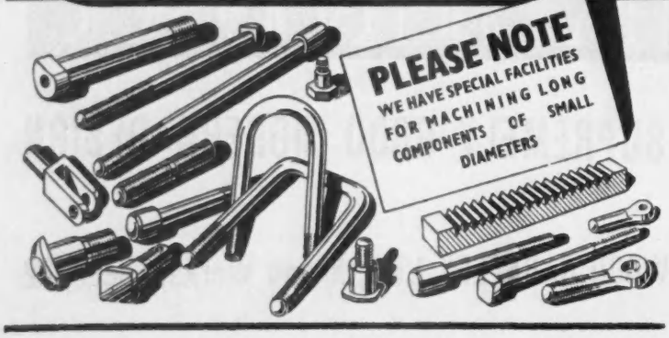

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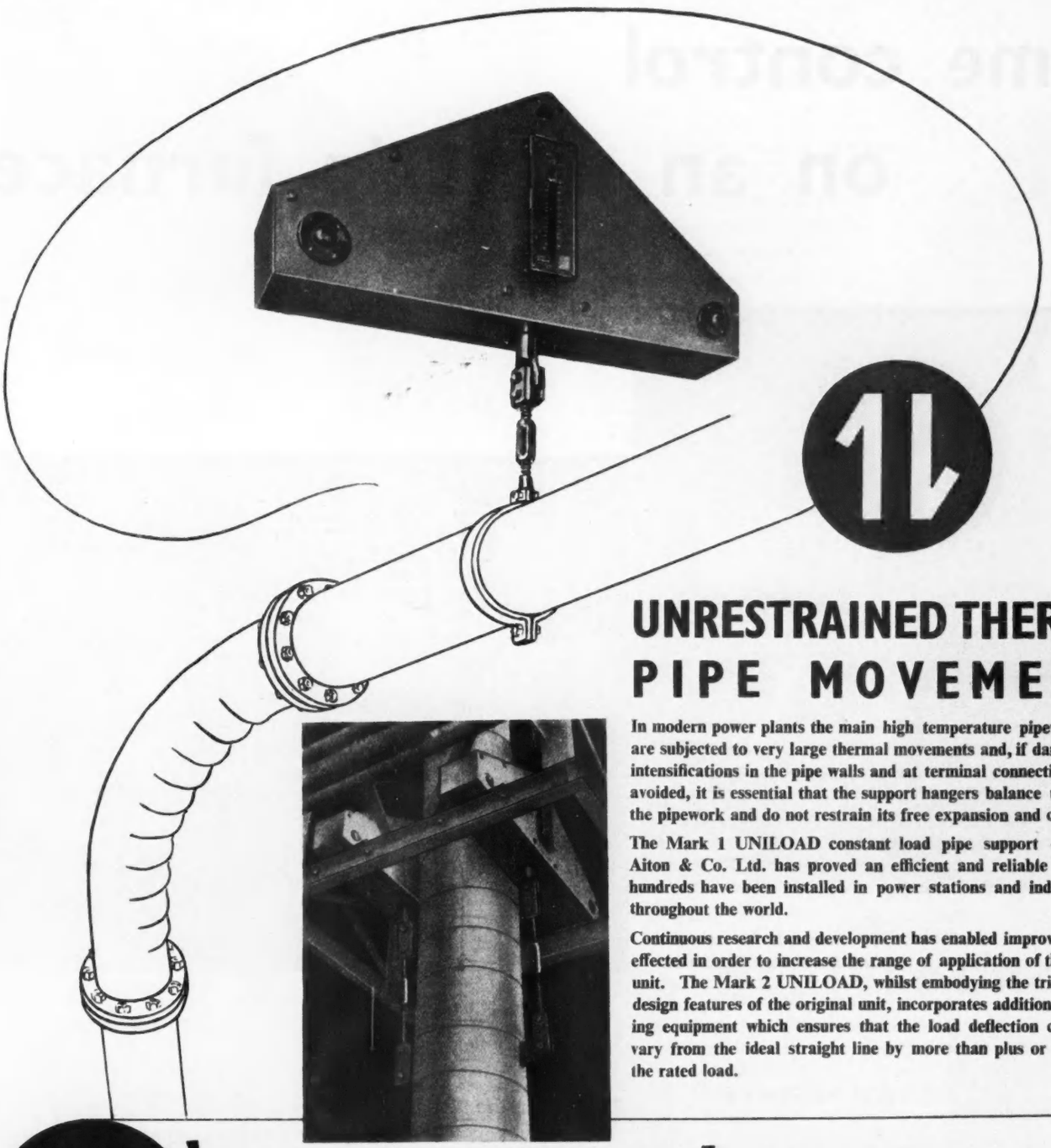

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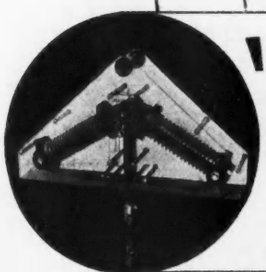
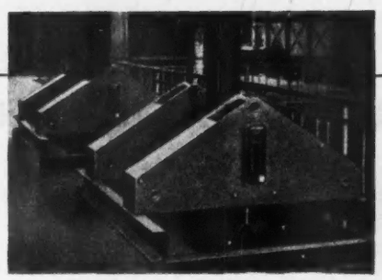


'UNILOAD' CONSTANT LOAD PIPE SUPPORTS

MARK 1 AND MARK 2



The Mark 2 UNILOAD is particularly suited to nuclear power plant or for any application where exceptional accuracy in load carrying characteristics are demanded.

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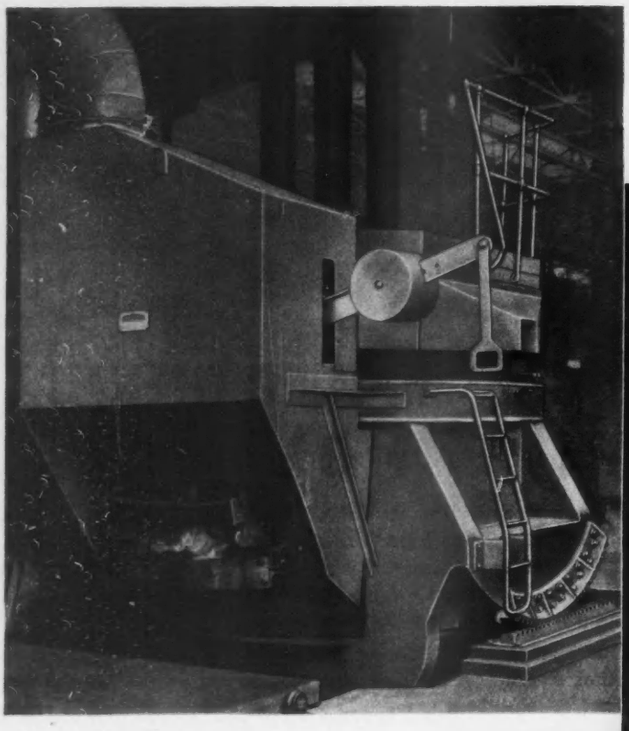

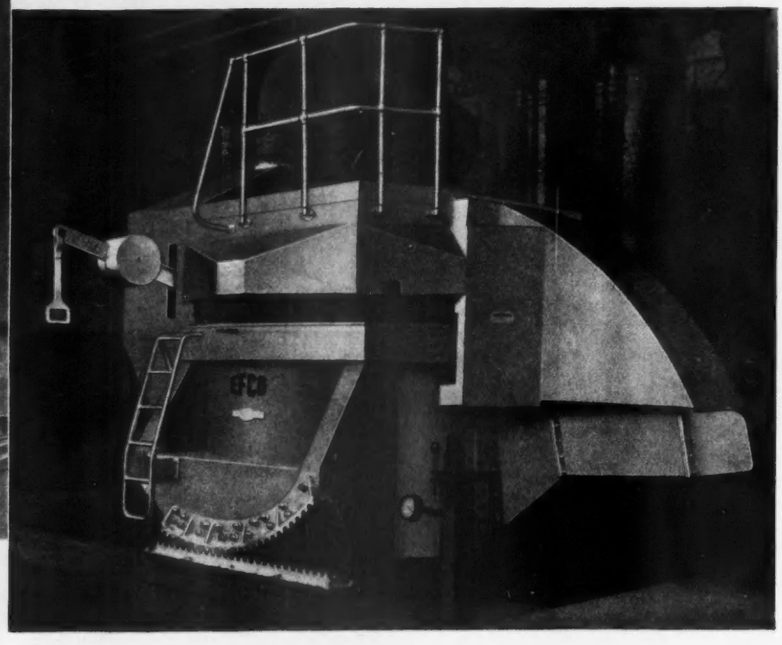

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Fume from the furnace is closely controlled by the fitted hood, which remains in place no matter to what angle the furnace is tilted. Easily removable subsidiary hoods over the pouring spout and the slagging door form a part of the complete unit and can be lifted off without disturbing the main hood for door and lining repairs.

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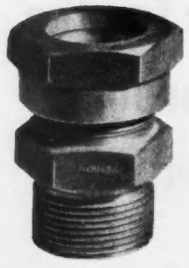

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pipe sizes 1" to 1½" and N.B
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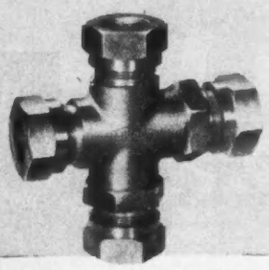

EQUAL CROSSES to suit O.D
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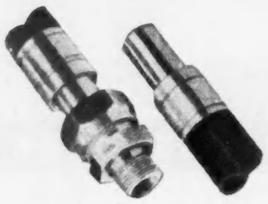

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COUPLINGS TYPE 1
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pipe sizes ¼" to 1¼"

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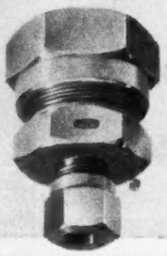
to suit O.D pipe sizes
⅛" to 1½" and N.B pipe sizes
¼" to 1¼"



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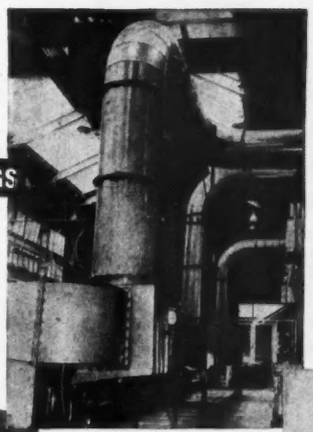

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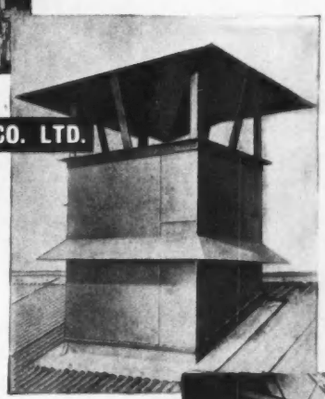

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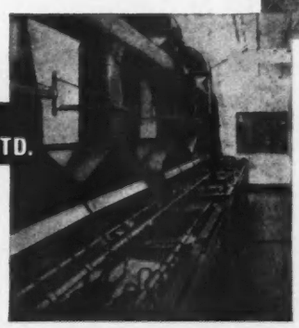

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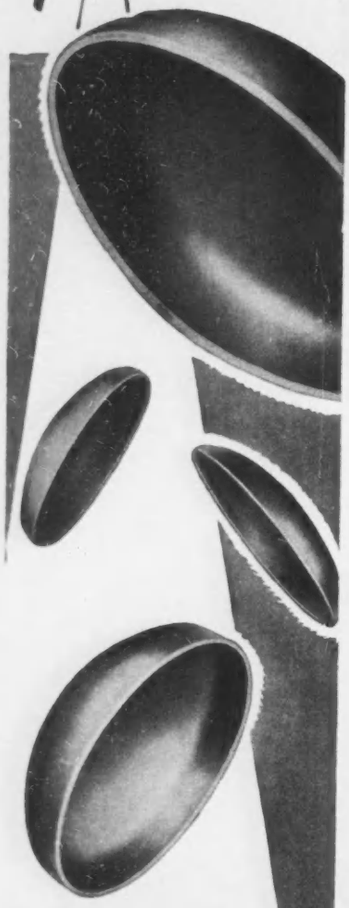

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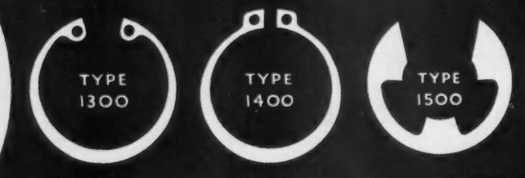

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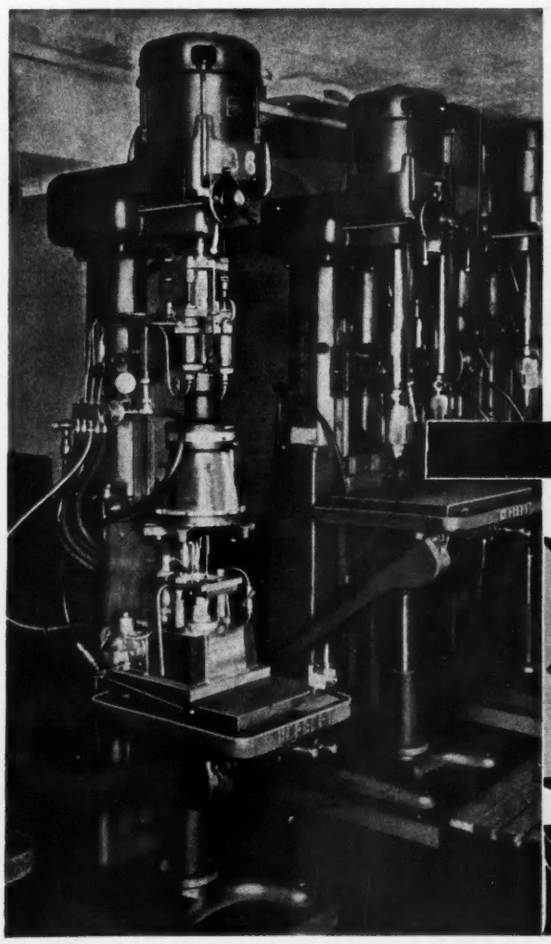

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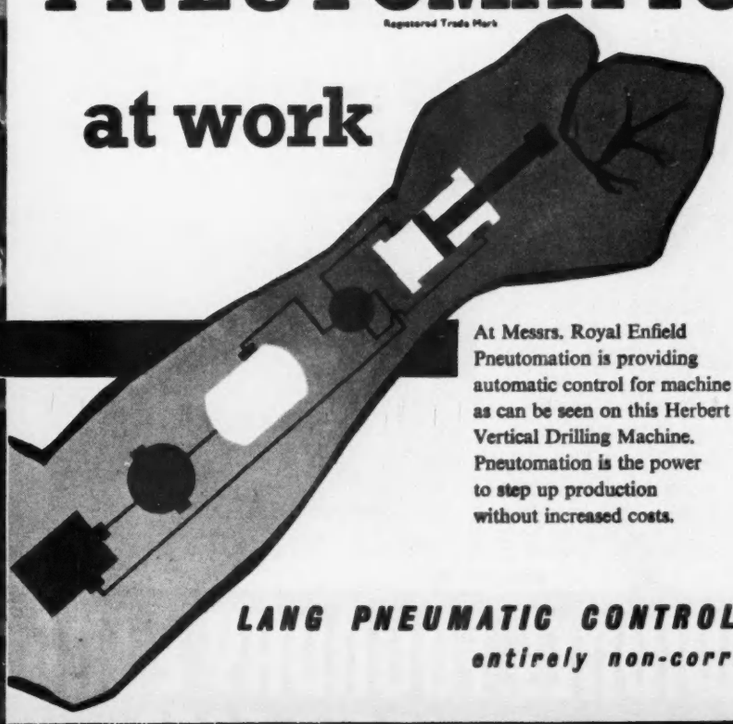

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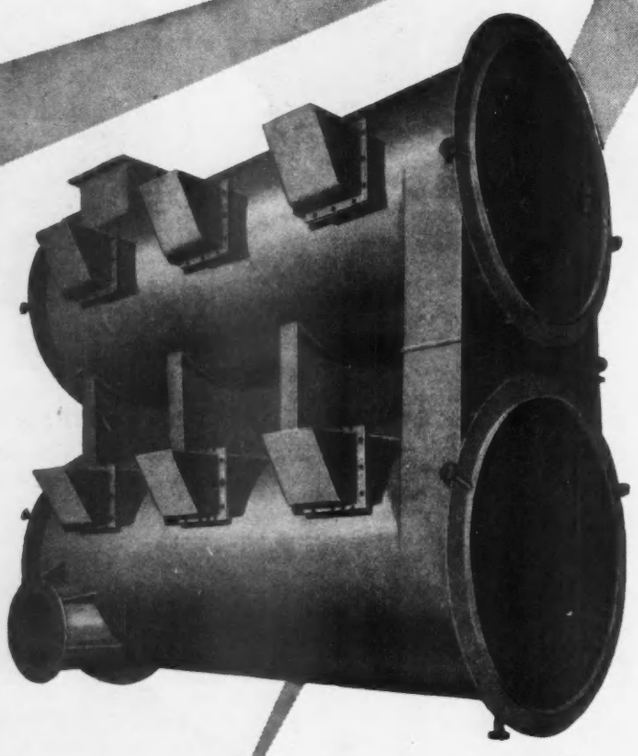

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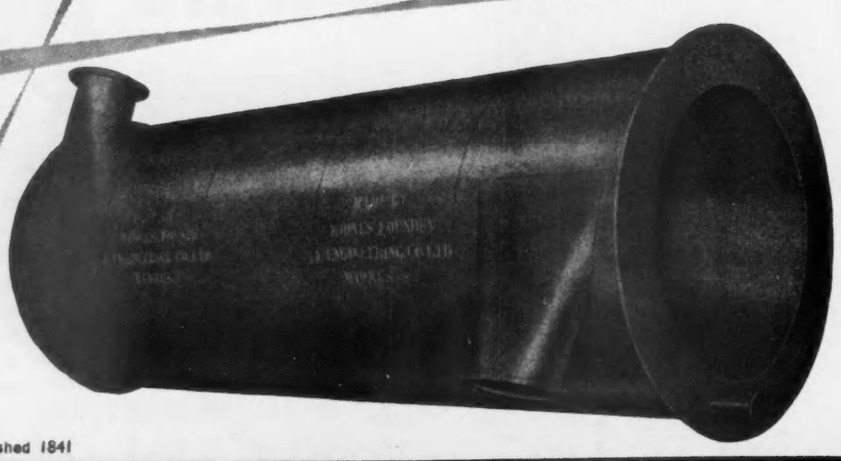
(LEFT) Mild Steel Casing, consisting of two shells; overall dimensions:—17ft. 6in. long, 9ft. 3in. wide, 17ft. 10in. high.

(BELOW) Mild Steel Helical cooler for SO_2, all welded construction; weight $6\frac{3}{4}$ tons, outer diameter 7ft., inner diameter 6ft., length 20ft.



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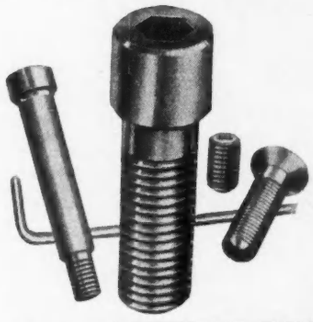

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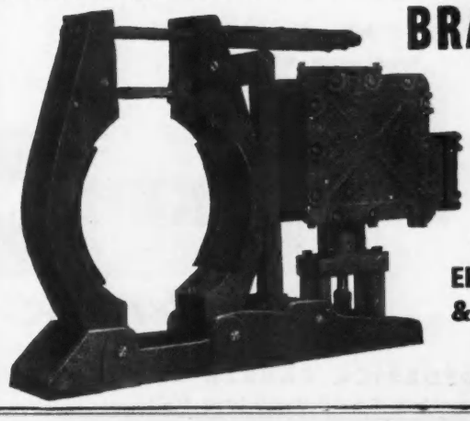

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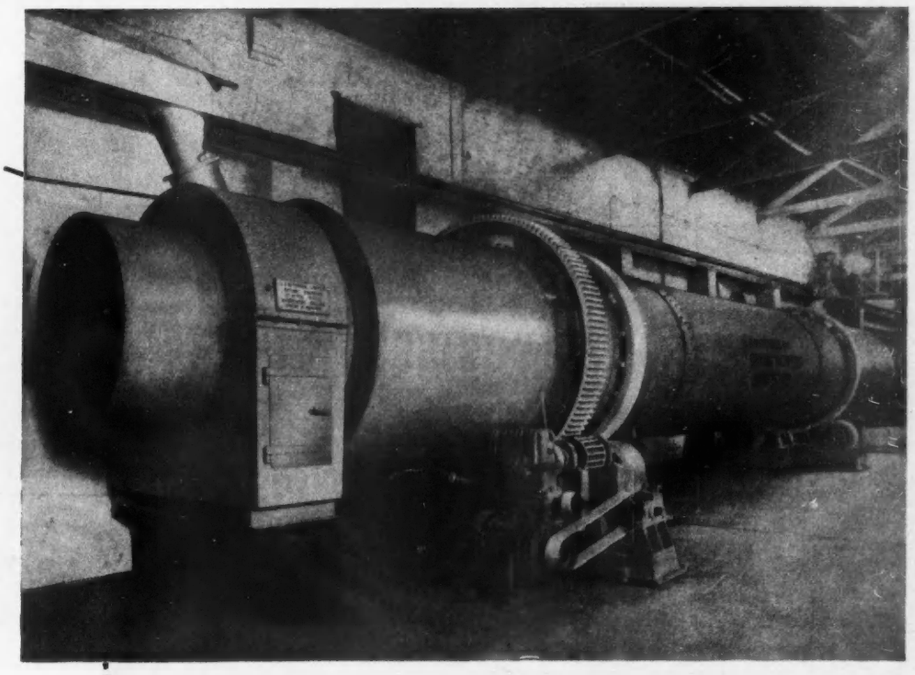

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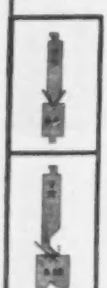

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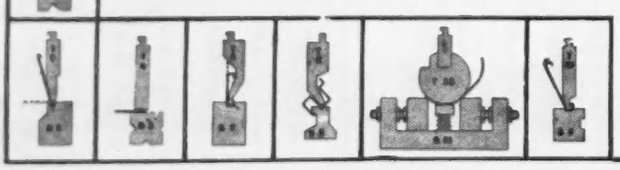

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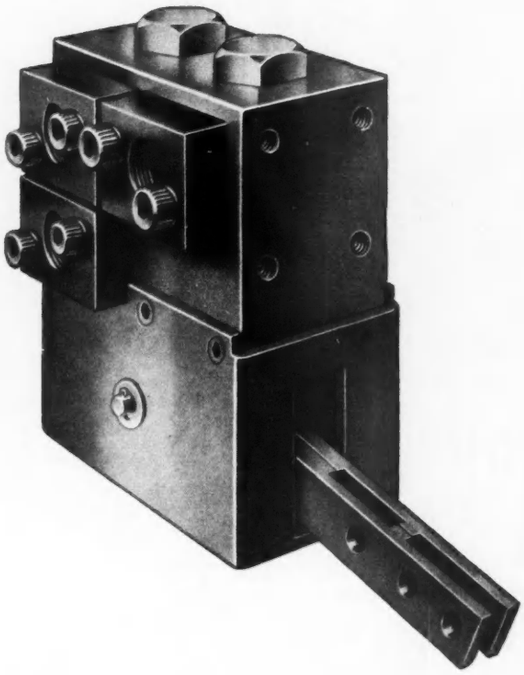

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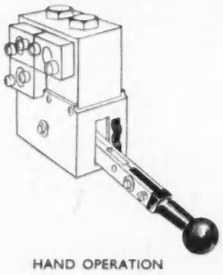
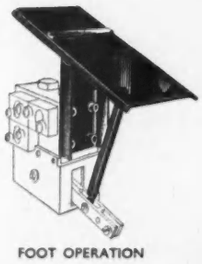
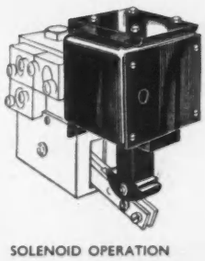


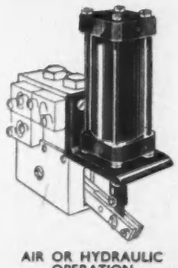
HAND OPERATION



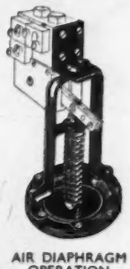
FOOT OPERATION



SOLENOID OPERATION



AIR OR HYDRAULIC OPERATION



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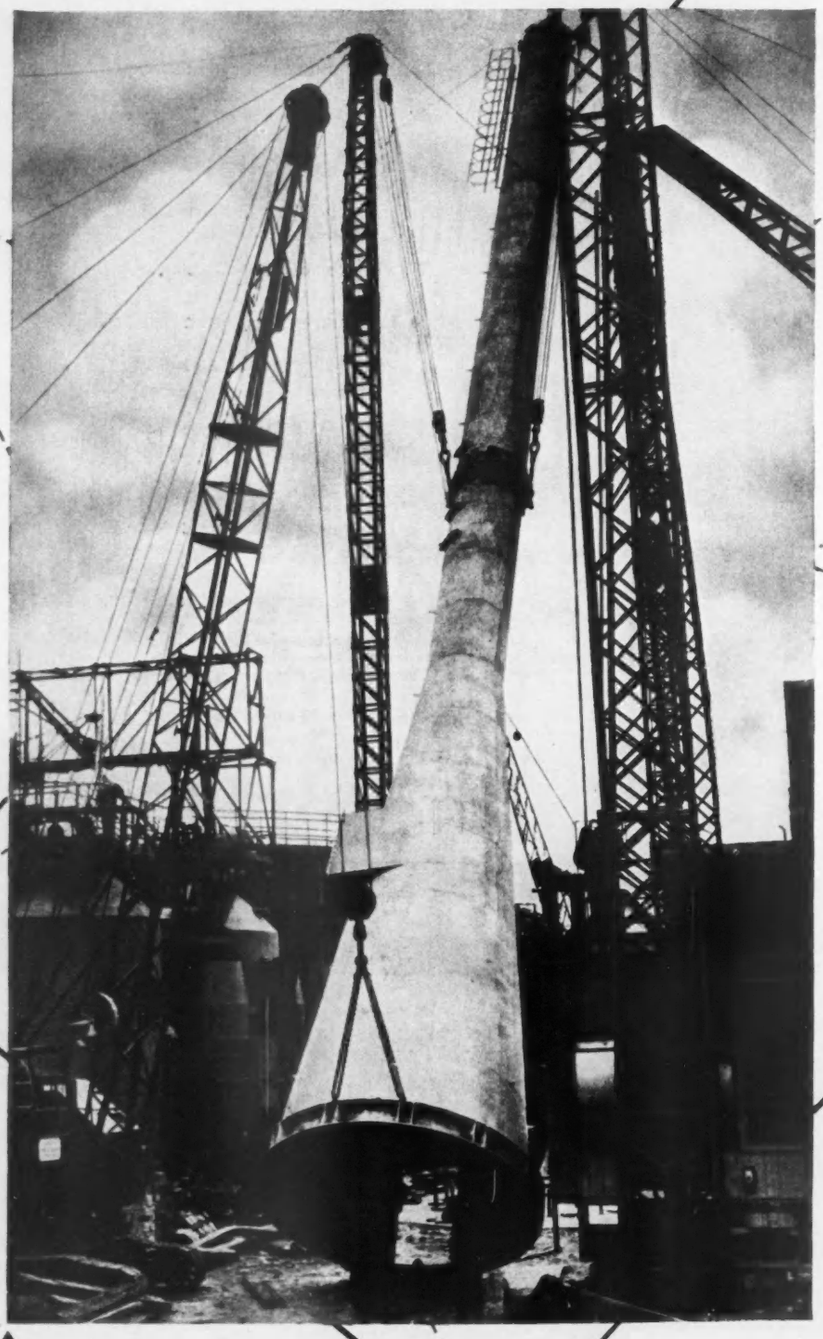

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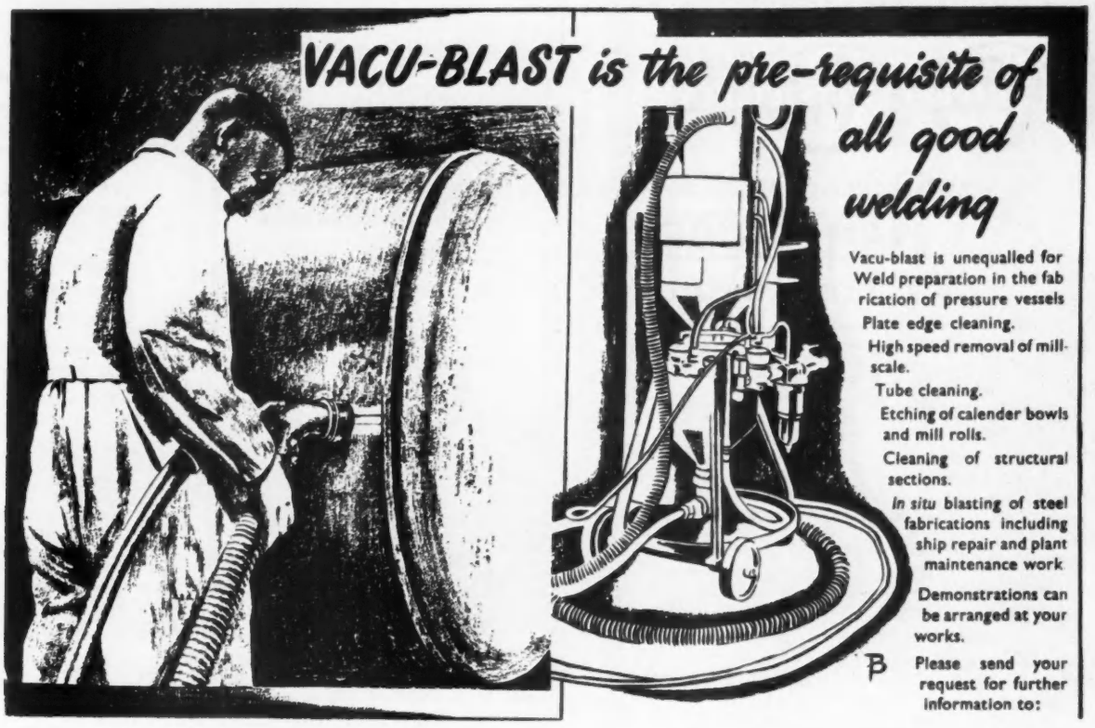

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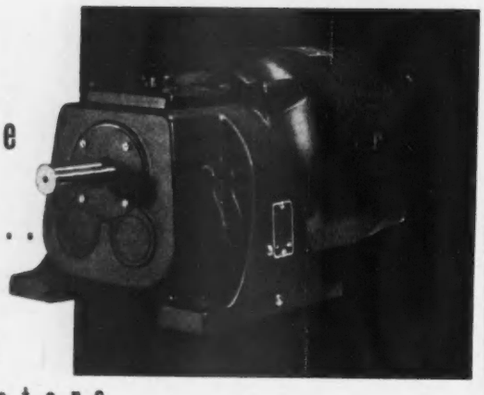

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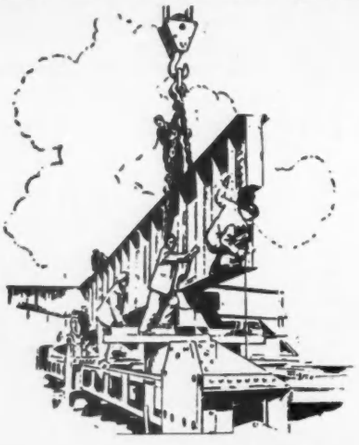

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Revolving Frame and Bridge Casting for 22-RB excavator.
Weight as cast 2 tons 14 cwt.
Sectional thickness max. 2½" min. ½".
Cast for Ruston-Bucyrus Ltd., by whose permission it is reproduced.

cast and welded for an important part

Although Lloyds make steel castings up to 25 tons in weight in one piece, they are nevertheless now producing heavy castings by welding groups of smaller castings to make one complete component.

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An example of the strength of the cast/weld method is the revolving frame and bridge casting illustrated. This is supplied to Ruston-Bucyrus Ltd. for their 22-RB excavator, and few steel castings have to stand up to the strains and stresses that are the daily lot of such machines.

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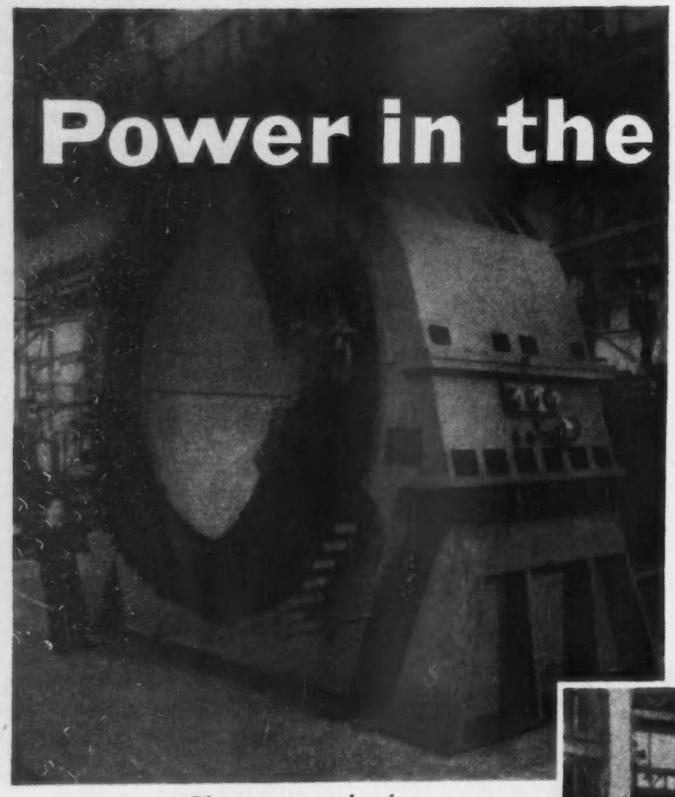
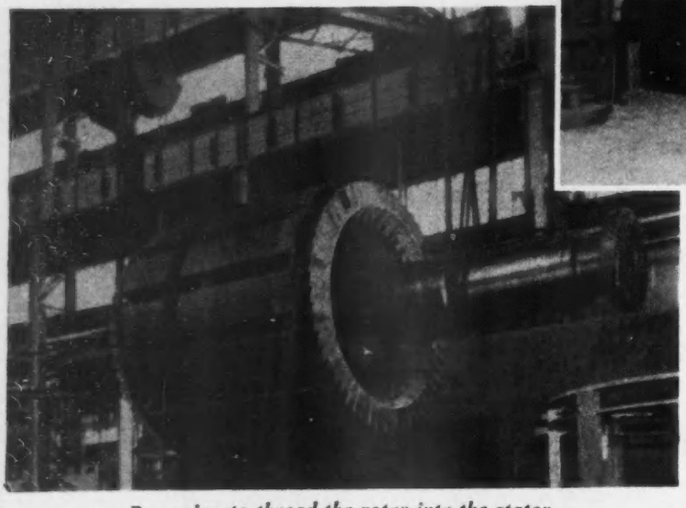


The stator completed

AURA

TWO 62.5 MVA and four 37.5 MVA horizontal water-wheel generators have been manufactured by Metropolitan-Vickers for the Aura hydro-electric station of the Norges Vassdrags-og Elektrisitetsvesen. The photographs illustrate the work in progress on the second 62.5 MVA machine.

The completed set being tested at full load wattless kVA



Preparing to thread the rotor into the stator

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Based entirely on genuine Sillimanite of highest purity, Sillmax 63/100 is the result of entirely new developments materializing the production of bondless Sillimanite bricks, i.e. a refractory containing 100% Sillimanite. Available in 3 grades.

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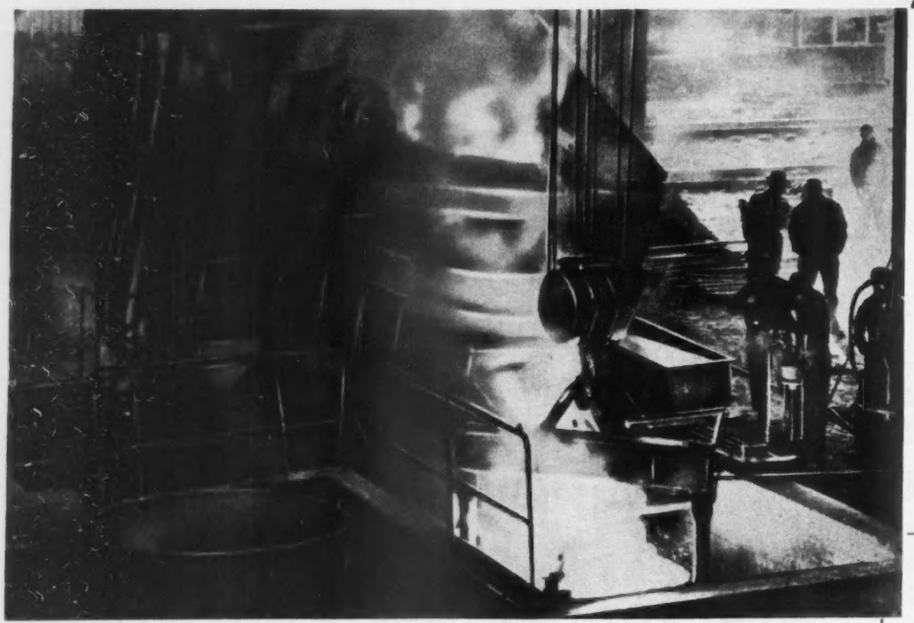
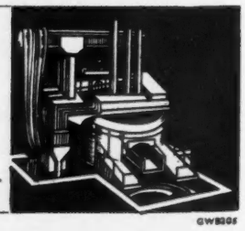


G.W.B.—Leone Tagliaferri 3-phase direct-arc melting furnace at Premier Steel Mills, Edmonton

Canada's booming construction industry needs all the steel it can get. To help meet this growing demand Premier Steel Mills Ltd., Edmonton, one of Canada's newest steel mills, recently went into production. Relying entirely on scrap, the mill covers an area of 72,000 sq. ft. and is equipped with the latest plant. Designed for continuous flow production, it is at present producing flats and bars for concrete reinforcement. "Heart" of the mill is the G.W.B.—Leone Tagliaferri 3-phase, direct-arc melting furnace,* which handles all the melting of the mill. With a nominal capacity of 10 tons and an 11 ft. shell, the furnace is rated at 4,700 kVA, and is designed for an output of 96 tons per 24 hours. In practice the output varies between 90—145 tons. Operation is hydraulic, by the Tagliaferri system which gives finer control and faster electrode operation. G.W.B. are proud to be playing an active part in Canada's industrial expansion. If you have a furnace problem, why not contact us?

* The outstanding performance of this G.W.B.—Leone Tagliaferri furnace, coupled with prompt delivery, led to an order for a second direct-arc melting furnace, which will be installed shortly.



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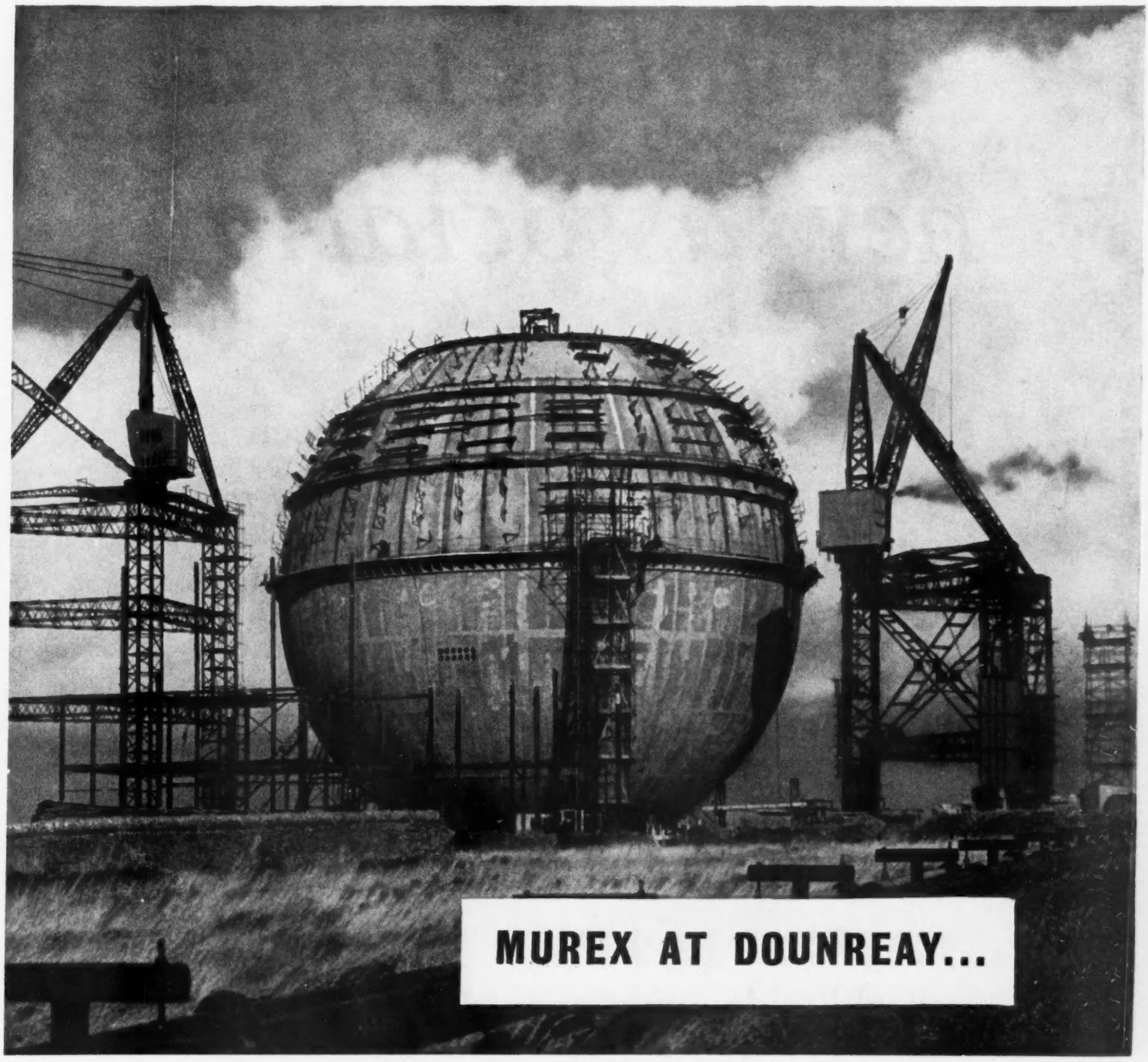

60 MILES OF FORTREX 35 ELECTRODES

Over 300,000 ft. of Murex Fortrex 35 Electrodes were used for welding the above sphere at the Dounreay Atomic Energy Plant. These electrodes were exclusively used for all the manual arc welding on this unique and massive sphere which is 135 ft. in diameter and is made up from nearly 300 plates. The sphere has been built by the Motherwell Bridge and Engineering Co., Ltd., Motherwell, to the most exacting requirements of the U.K. Atomic Energy Authority. For such applications only the best electrodes can be used. Murex electrodes are at your service.

Other contractors at Dounreay using Murex electrodes include Alex. Findlay Ltd., Matthew Hall and Co., Ltd., Head Wrightson and Co., Ltd., John Thompson Ltd., Thos. W. Ward Ltd., and Whatlings Ltd.

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E26

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An all-British team has now been formed between RUSTON & HORNSBY LTD. of Lincoln and J. L. KIER & COMPANY LTD. of London for the design, development and construction of Nuclear Power Stations of 5 to 25 MW output.

The association of RUSTON and KIER is one of established reputations and world-wide experience in mechanical and civil engineering—a powerful combination formed in the interests of world development.

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J. L. KIER & CO. LTD., NUCLEAR DIVISION, 7 LYGON PLACE, GROSVENOR GARDENS, LONDON, S.W.1

conveyed safely

To convey safely *care* has to be taken; and with conveyor belting the right point at which *care* should be taken is at the design, development and manufacturing stages. After that it should take *care* of itself, the people who work with it and the load it carries. The unique research and manufacturing facilities of Rubber Improvement Ltd. make certain that Leonex P.V.C. Multiply Conveyor Belting is produced with such *great care* that long life, dependability and safety are ensured.

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MOLYBDENUM DISULPHIDE ADDITIVE EXTENDS EFFECTIVE LUBRICATION

Molybdenum Disulphide greases are now being employed by all sections of British industry to overcome serious lubrication problems associated with extreme pressures, fretting corrosion, impact shocks, and arduous working conditions where oscillation and reciprocation are involved. Their use results in substantial reduction of wear, much lower starting torque and greatly improved running. This is clearly demonstrated by analyzing the following test data where in all cases the addition of MoS_2 extended the effective lubrication of the base lubricant.

Four tests show how MoS_2 reduces wear

1. SHELL 4-BALL EXTREME PRESSURE TEST

(see illustration top right)—MoS_2 addition reduces wear more than 50% and increases load capacity by about 70% over base grease.

2. FALEX 2-HOUR WEAR TEST

The chart below shows how MoS_2 sustains lubrication, as proved by a reduction of 500 per cent in average wear.

Grease	Loss in Weight of Specimen
Lithium-base	1,000 mg.
Lithium-base plus 2%MoS_2*	1·98 mg-average of 3 runs

3. TIMKEN ENDURANCE TEST

(see illustration bottom right)—MoS_2* sustains lubrication well beyond the capabilities of the base grease alone, and at a lower temperature than conventional E.P. grease.

4. SIMULATED SHACKLE BOLT SERVICE TEST

Oscillating friction machine—3%MoS_2* addition virtually doubles the effective lubrication of a lithium base chassis grease—is far more effective than conventional additions.

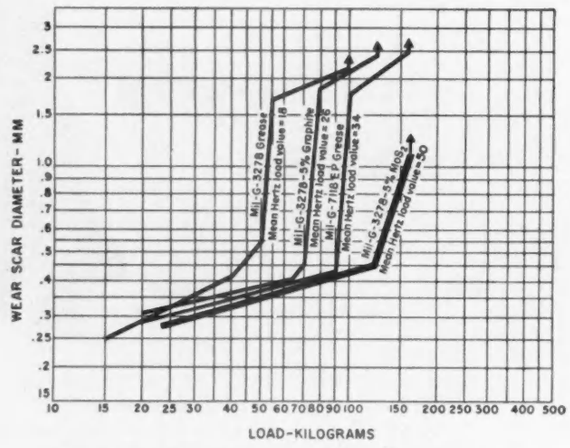
Hours to failure—average of 2 tests

Additive	None	3%MoS_2*	5%ZnO	15%ZnO
Dry	350	564	336	555
Wet	162	264	109	85

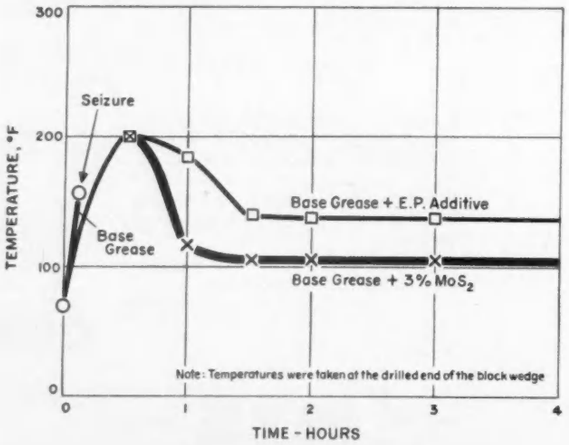
* Fine particle size.

Molybdenum Disulphide greases are manufactured in the U.K. by a number of specialist producers, whose names can be obtained, together with a copy of "MOLY-Sulfide as a Grease Additive", from :—

CLIMAX MOLYBDENUM COMPANY OF EUROPE LIMITED
99 PINSTONE STREET, SHEFFIELD 1


WEAR SCAR DIAMETER - MM
LOAD - KILOGRAMS
Mil-G-3278 Grease
Mean Hertz load value = 18
Mil-G-3278 - 5% Graphite
Mean Hertz load value = 26
Mil-G-7118 E.P. Grease
Mean Hertz load value = 34
Mil-G-3278 - 3% MoS2
Mean Hertz load value = 50

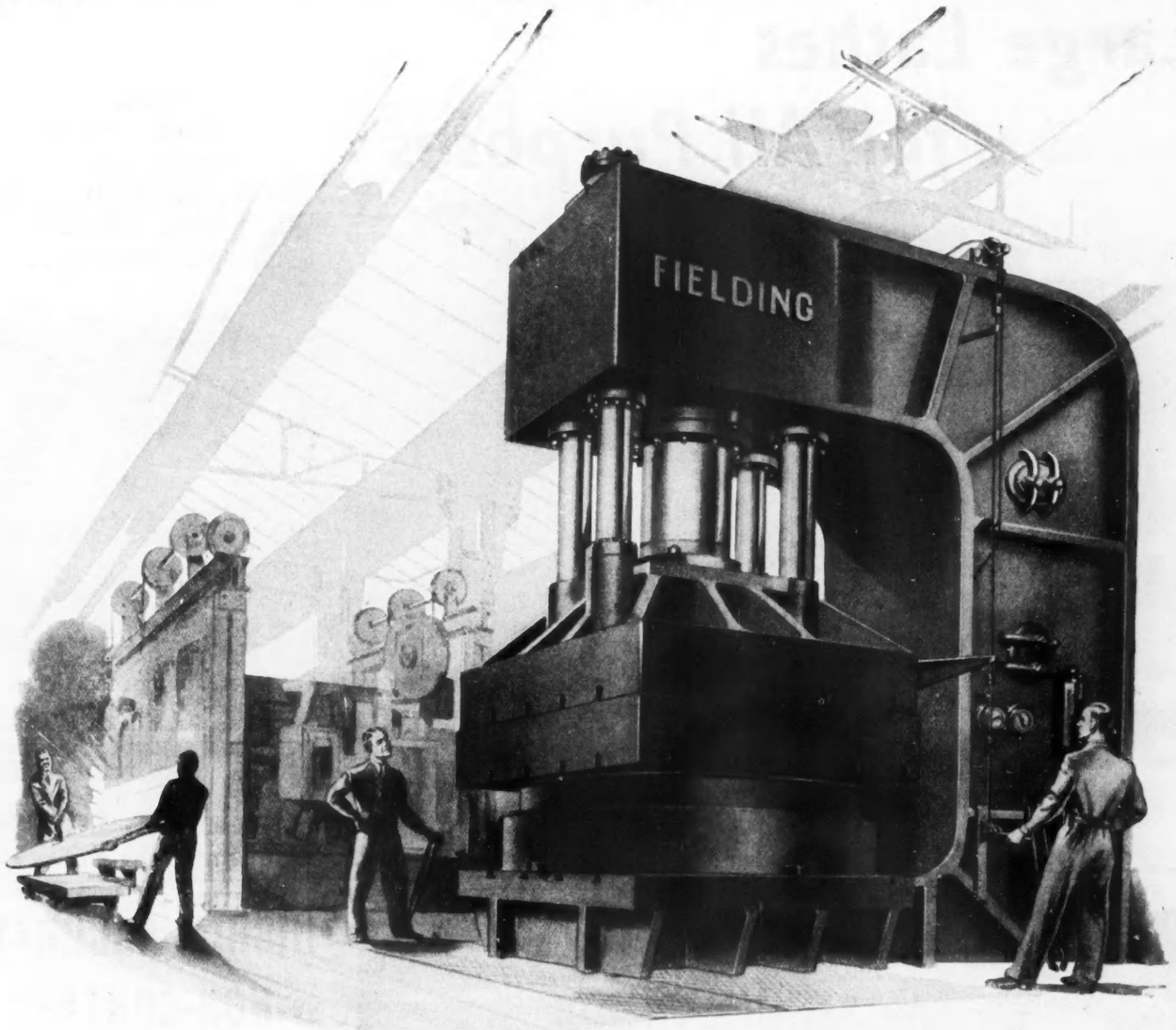
4-ball E.P. test shows the superior extreme pressure properties of MoS_2 grease over the same grease without additives. In the same test, grease containing 5% graphite had a mean Hertz load value of 26: the conventional E.P. grease Hertz value was 34.


TEMPERATURE, °F
TIME - HOURS
Seizure
Base Grease
Base Grease + E.P. Additive
Base Grease + 3% MoS2
Note: Temperatures were taken at the drilled end of the block wedge

Timken endurance test clearly shows how MoS_2 functions when added to a base grease. With base grease alone, the specimen seized in about 10 minutes. With MoS_2 added, lubrication was effectively sustained throughout the test at a reduced temperature of about 100°, compared with a temperature of about 130° for the conventional E.P. grease.

MOLY-SULFIDE†

† MOLY-Sulfide is a Climax brand name



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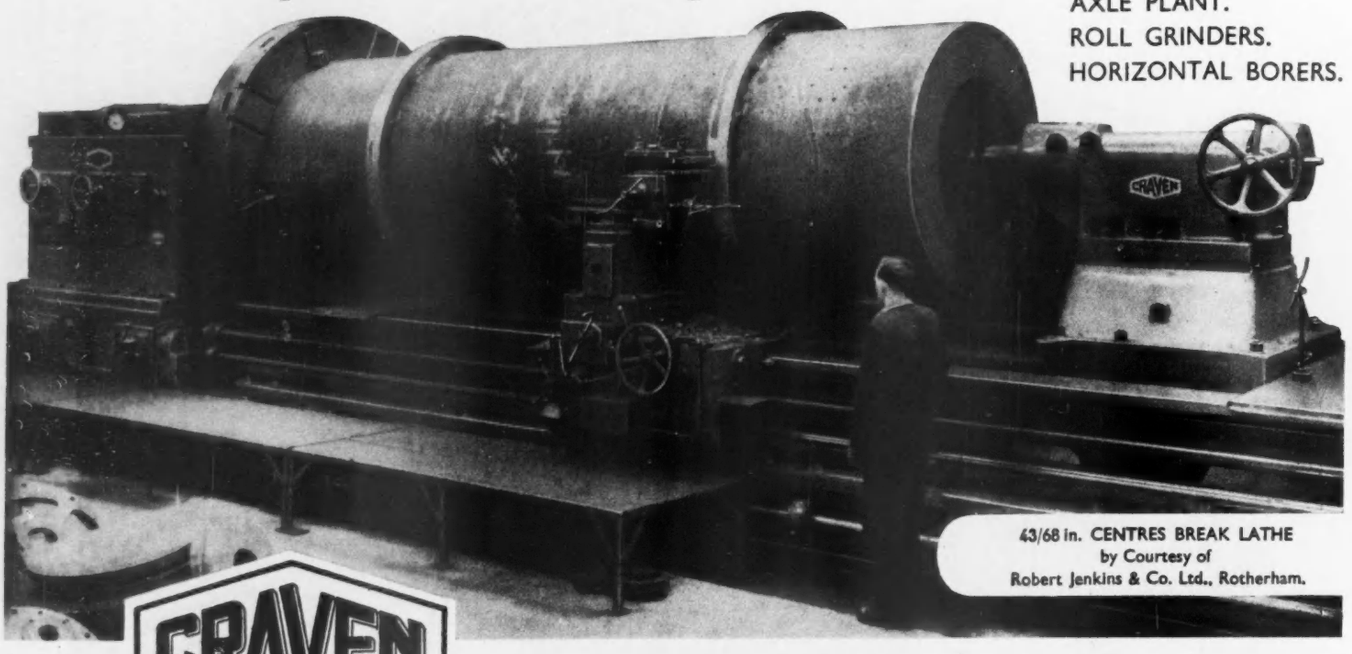

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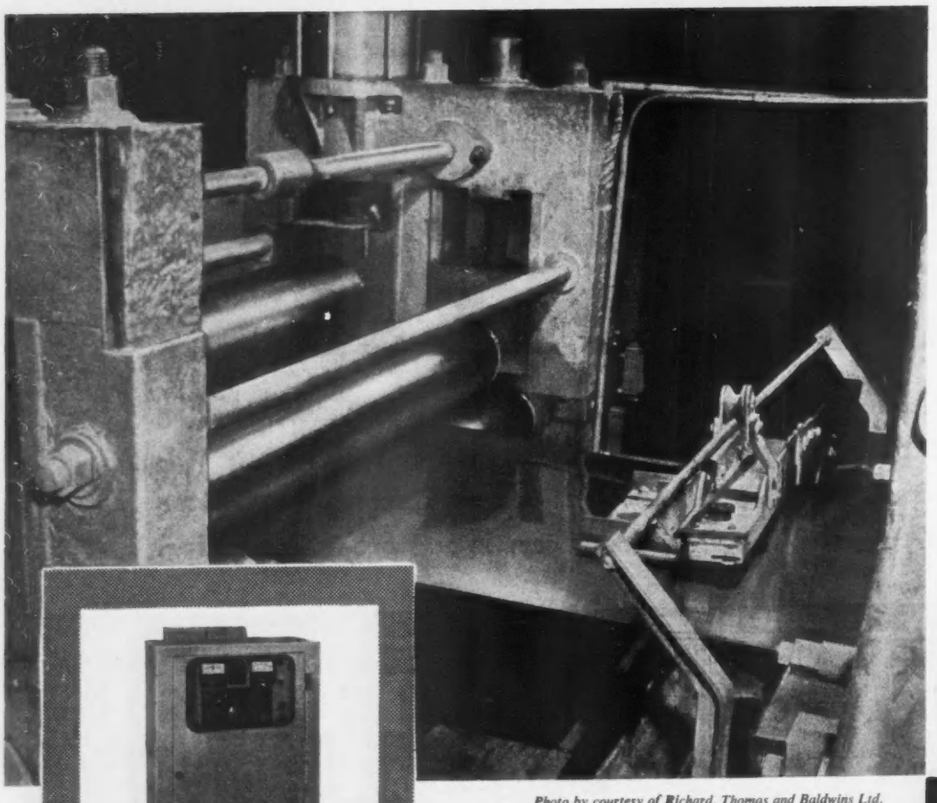

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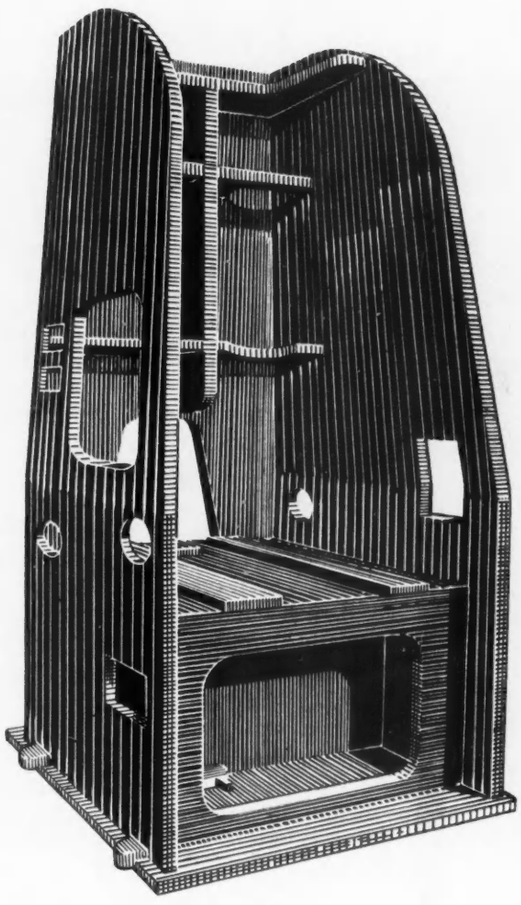

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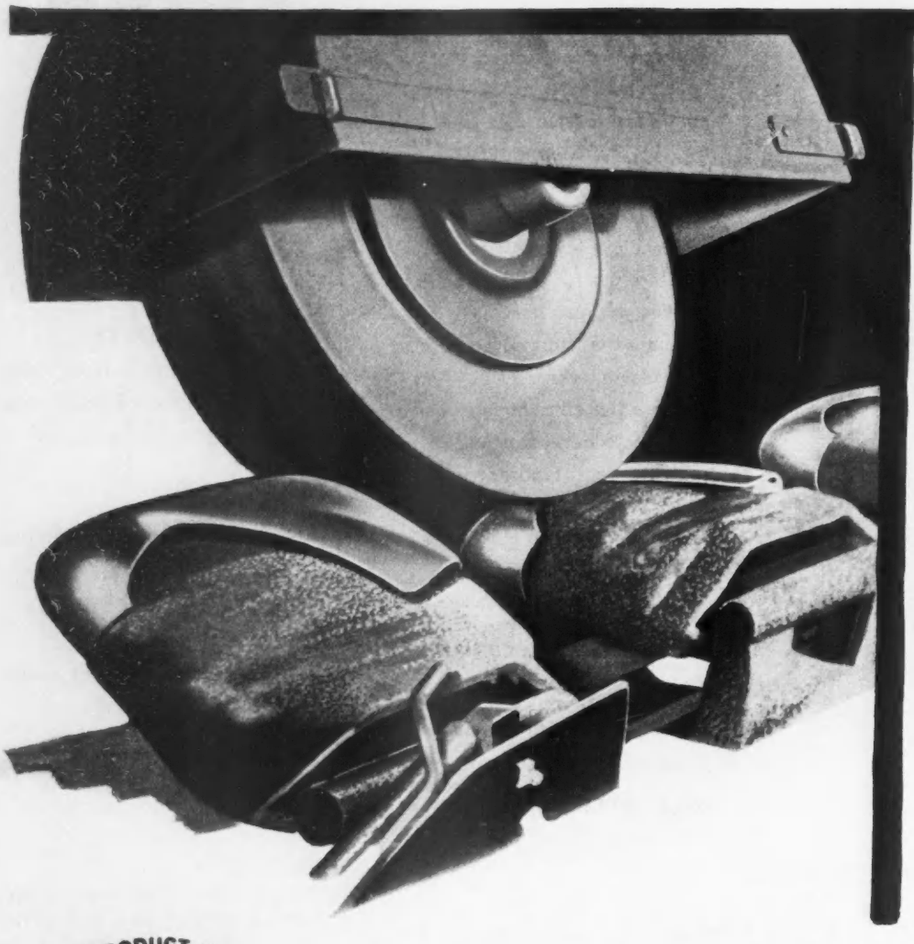

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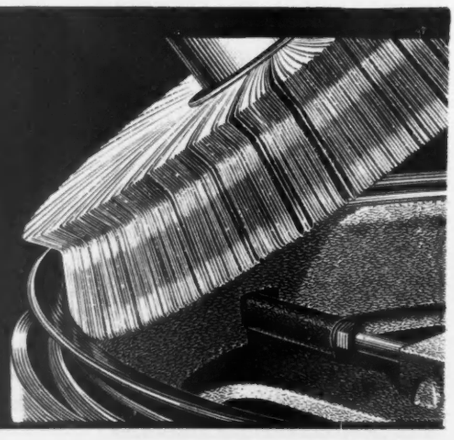

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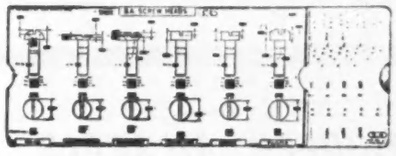

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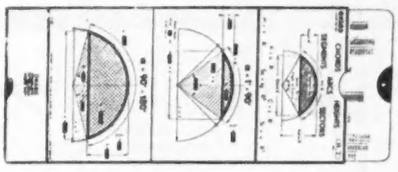

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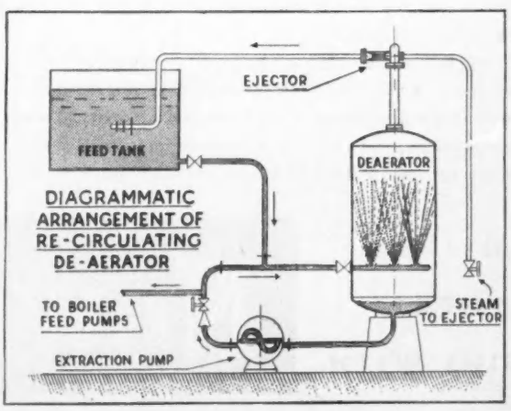

The illustration shows a Hick Hargreaves De Aerator Size 300S. at the Margam Works of the Steel Company of Wales Ltd.
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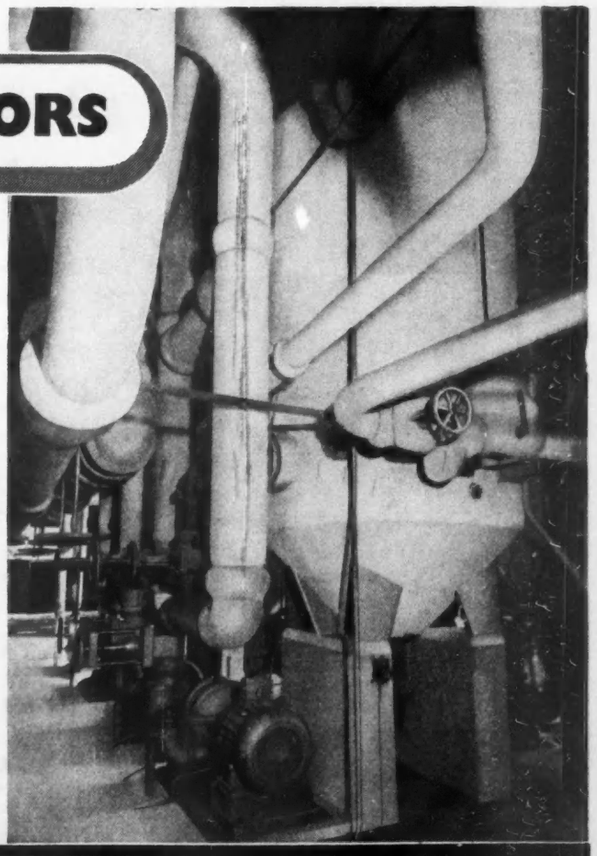

H126

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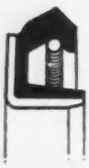
TYPE 11 P/B

As type 11 P but with the casing covered with rubber. Interchangeable with metal case seals.



TYPE 23 P

An external seal used when fitting conditions prevent the use of 11 P or 11 P/B seals.

TYPE 12 P

A rotary shaft seal used to separate two different fluids.

TYPE 13 P

Similar to type 12P but without a spring on the second lip which serves as a dust excluder.

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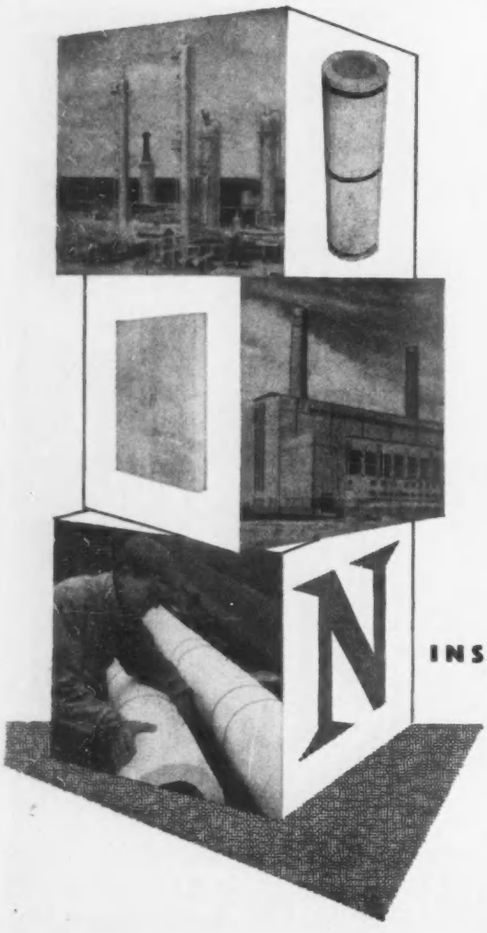

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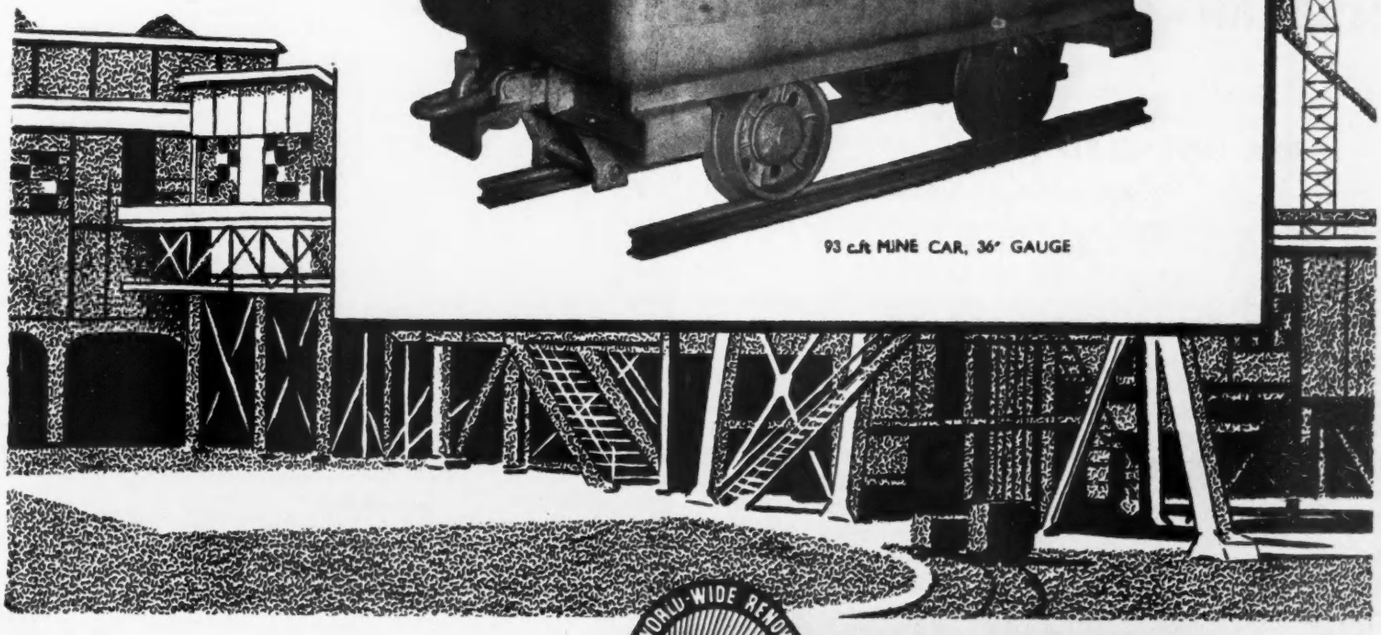

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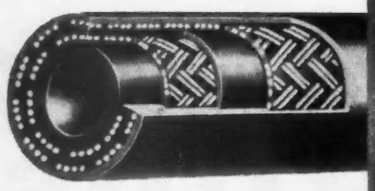
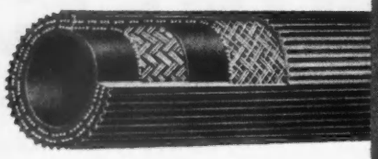


STYLE A *for service where oil mist may be present in the line, and where operating pressures up to 325 lbs. per sq. in. are used.*



STYLE B *for general, light and medium pneumatic tool service and working pressures up to 210 lbs. per sq. in.*

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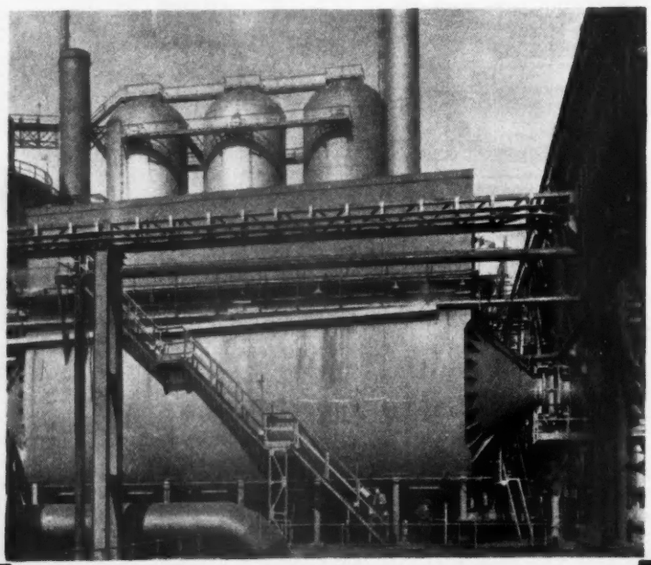

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THE ENGINEER

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"MECHANICALS" MIDSUMMER MADNESS

There is an astonishing dualism about the Institution of Mechanical Engineers. No doubt it arises out of its rather rapid conversion from a quite intimate society of engineers when the first world war began, to a great national body by the time the second world war ended. As an Institution it is now, indeed, international. It belongs to a European and U.S. Conference of Engineering Societies; it plays a large part in a Conference of Commonwealth societies ; it presents its major award, the James Watt Medal, at least as often as not to foreigners and it invites distinguished engineers from any part of the world to address its meetings. In none of these activities is it parochial ; and were a paper to be offered to it by an unknown engineer from any part of the world the merit of the paper would be judged without any reference whatsoever to the nationality of its author. All of this activity is in tune with the important place the Institution now occupies not merely in national engineering affairs but international engineering affairs as well. But when the Institution comes annually to consider where it should hold its Summer Meeting something goes sadly wrong. A midsummer madness develops ! Quite suddenly and almost inexplicably the Institution harks back to its past and tries hard to pretend it is still a small society of engineers of little account in its country's affairs and of no account at all internationally. Only once since the war—in 1954—has the Institution taken its members abroad ; and even then—we admit it was a good beginning because some 20 years had elapsed since it had been abroad before !—only just across the Channel to the Netherlands. We had hopes then that the Institution was beginning to become "adult" and international in so far as Summer Meetings were concerned. But apparently it is not so. For the holding of these Summer Meetings it still clings to the idea that nowhere in the world can they be better held than at home. It is either unwilling or afraid to take its members abroad. It won't grow up !

In the past—50 years ago and more—the Institution was largely right in its policy. Britain was then "the workshop of the world" and its members could learn more about engineering by holding a meeting in one or other of our great industrial cities than by going abroad. A very occasional visit to the Continent sufficed. But the situation is now quite changed. Engineers in this country have much to learn from what engineers in Western Europe are doing. We mention Western Europe in particular because it is Western European firms especially that compete with British engineering firms in export markets ; because Western European countries are within easy reach of our country ; because engineering problems in design and production in Western Europe are closely akin to those ruling here, though the solutions adopted are often different ; and because a European Common Market is coming into being with which this country may be linked by a European Free Trade Area. In the past the Institution had no need to think out what a Summer Meeting was for ; because when held in this country it both brought members socially together and helped them to gain information about the best engineering practice in the most highly industrialised country in the world. But to-day the purpose of a Summer Meeting needs to be thought out afresh. For the world has changed quite a lot since the opening of the century. Increasingly, it seems to us, these meetings are becoming—because they are held in this country—mere local meetings attended by the president and as many members of Council as can "spare" the time and by a relatively very small band of stalwarts from all parts of the country. The bulk of the members attending are made up of those who live near the meeting place. No doubt, it is all very flattering for the local branch of the Institution. But is it of very much use to the membership as a whole ? This year, for example, the Institution is to hold its Summer Meeting in Cardiff. It is an excellent city and no doubt the South Wales Branch is delighted to have been chosen to receive the members. But both city and branch must forgive us for remarking that we would see far more point in holding the meeting somewhere on the Continent than in Wales. It should be added that we say so despite our particular liking for Wales and Welshmen.

To break this custom of the Institution of holding its Summer Meetings in this country with only a very occasional excursion abroad requires that a tradition formulated well back in the nineteenth century shall be broken and something which has since become customary shall be altered. It is there, of course, that the difficulty lies. For traditions and customs are not easily broken, once established, even when they can be seen to be a hindrance to advance. Traditionally, the choice of a venue falls to the incoming President. Very naturally it tends to fall on a place from which he can take the members to see his own works or to firms closely linked with his own work. Customarily, the question of venue is coloured by the natural desires of local branches to receive the members. Ordinarily, therefore, the place at which the Summer Meeting is held is decided by a compromise between the desires of the President and a consideration of which local branches have least recently been honoured. Where it would be best to go in the interests of members as a whole and in relation to contemporary developments in mechanical engineering tends to get neglected! Thus, for our part we do not regard this method of choice as befitting a great national and international Institution. For, after all, the Institution is no longer a small and relatively unimportant society of engineers. It has grown up. It is now a great qualifying and educational body whose job it is to propagate amongst its members know-

ledge of the science and art of engineering and to bring together engineers to study that science and art wherever it may best be studied. Seen in that light, concentration upon the holding of Summer Meetings in this country alone is almost outrageously parochial in days when a Common Market is being created in Western Europe, when there is discussion of a Free Trade Area, when engineering researches of many kinds are conducted internationally and when engineering advances are as frequently made on the Continent as they are here. The tradition and the custom urgently need altering. The Summer Meeting of the Institution in our view should be held on the Continent at least as often as in this country ; and its venue (not without reference to the President, of course) should be settled by the Council, taking into account many other contemporary factors besides local branch desires. Local branches should get used (and would get used) to less-frequently being honoured.

CLEAN AIR ACT

At the end of last week the Minister of Housing and Local Government made an order which effectively brings into operation as from June 1 all the remaining provisions of the Clean Air Act of 1956. Many of the provisions of that Act came into force at the beginning of 1957. The principal provision effective from June 1 under the new order is that it will become an offence, punishable by fines up to £100, to emit dark smoke from chimneys and it will be a requirement that any practicable means shall be used to minimise the emission of grit and dust. The rule applies to industrial chimneys, to those of shops and offices, and to those above domestic premises. In certain respects it applies also to ships and railway locomotives. Dark smoke is defined as smoke as dark as or darker than Shade 2 on the Ringelmann Chart. The Minister is soon to make Regulations prescribing the permitted limits for emissions of dark smoke and an order to extend the lists of works and gases controlled under the Alkali Act.

It would, of course, be quite absurd to suppose that as from June 1 next there will be any startling cleaning of the air above the British Isles as a consequence of the coming into full force of the Clean Air Act. It is very much more probable that there will be no immediate effect whatever ! For though the ban on dark smoke becomes effective the Act very wisely includes a number of escape clauses. No attempt is being made to compel industry to do something that cannot, with the best will in the world, be done immediately, following upon a stroke of the pen. Industry is given time to make the changes to its fuel-burning appliances which will result in lessening the output of smoke. As much as seven years can pass before the full rigour of the law will be enforced. Thus many firms with obsolescent plants, provided they can satisfy local authorities of the impracticability of doing better, will need only to be careful when the time for replacement comes that more suitable plant is obtained. They will be wise in doing so to get the prior approval of local authorities (which are responsible for implementing the Act) for the design adopted. All new plant installed must comply with the provisions of the Act. Industry, again provided the local authority can be satisfied that delay is unavoidable, is given all that number of years, also, to modify comparatively modern plant not complying with the Act. In general, therefore, providing local authorities use their powers with discretion, we do not believe that any very onerous load is being laid upon industry, the more so that the emission of dark smoke is a sign of inefficient combustion and thus of wastage of fuel. But now that the Minister has made the Order all industrial firms would be wise to make themselves fully acquainted with the provisions of the Act. Amongst other sources of Ringelmann charts we learn that the National Society for Clean Air, Palace Chambers, Bridge Street, London, S.W.1, is able to supply them at 2s. 8d. each or 27s. 6d. per dozen, post free.

TEACHERS FOR TECHNICAL COLLEGES

In 1956 a special committee on the supply and training of teachers for technical colleges under the chairmanship of Dr. Willis Jackson was set up by the Minister of Education. In its report, it pointed out, among other matters, that, as a consequence of the plans coming to fruition for expanding technical education, complementary action needed to be taken to increase the number of teachers in technical colleges and to ensure that their quality was sufficiently high. Following on one of the committee's recommendations the Ministry of Education has now decided that the number of places available for students who wish to train to become technical teachers is to be increased by over 60 per cent and that to attract more prospective teachers to take courses in the three training colleges at Bolton, Huddersfield and London substantially higher grants are to be made available. The Minister is consulting the local education authorities concerned about building work which may be necessary to expand training facilities. The details of the new grants are not yet known, but the ruling principle appears to be that a married student with one or more children shall not be worse off financially than someone earning the basic minimum salary of a Grade A assistant in a technical college, some £475 per year. This is undoubtedly a move in the right direction. But as the technical colleges will need, over the next five years, to recruit over 2000 new full-time teachers annually to make good losses and provide for a net expansion of about 1400 teachers each year, it does not go nearly far enough. For larger numbers of teachers are recruited directly from industry than from the training colleges. It is satisfactory to learn, therefore, that arrangements intended to improve recruitment from that source are being taken, that a proposal for establishing courses of training for technical teachers already in service is being studied and that the Minister is giving consideration to the amount of financial assistance which could be offered to teachers taking such courses. A circular recently issued by the Minister refers to the provision of better amenities for staff, and to the appointment of more clerical, laboratory and workshop assistants. Periods of release from teaching duties are recommended, in which teachers may study for first or second degrees or for the Diploma in Technology. Teachers are also encouraged to return to industry for short periods to refresh their experience. They should also be given leave of absence with pay to carry out special studies or surveys, or to visit teaching institutes abroad. At the same time, the Minister has endorsed the committee's view that closer relations between the colleges and industry are needed, with a view both to making it easier for staff to transfer from industry into full-time teaching, and also to securing the release of industrial staff to teach part-time in the colleges during the day. Authorities are also urged to extend their recruitment arrangements as widely as possible, to include late entrants of various kinds, such as releases from the Armed Forces, men from research

organisations and married women. All this activity flows from the recommendations of the committee. Its report has proved so valuable that the Minister has thought it wise to set up a similarly constituted standing committee, again under Dr. Willis Jackson as chairman, to keep under permanent review the supply and training of teachers. It becomes one of the standing committees of the Minister's National Advisory Council on the Training and Supply of Teachers.

ADMIRALTY REORGANISATION

The First Lord has now made it clear that the recently announced reorganisation of the production departments in the Admiralty is in no way connected with any decisions which may be reached on the future of the Royal Dockyards. Over a number of years new departments have been established at the Admiralty staffed by personnel with the specialised knowledge required for dealing with new technical and scientific problems. The older departments, however, still remained. This has resulted in various departments specialising in certain subjects instead of dealing objectively with broad functions. At the same time, the Controller (Third Sea Lord) has been receiving reports from them and from a large number of other departments, and has had, almost alone, to draw all these specialised interests together to make a workable end product. In future, some eighteen different departments which have been reporting direct to the Controller will be organised in four main groups, each under a Director General. Three of the departments—Naval Construction, Weapons and Radio, and Air Material—will come directly under the Controller. The fourth—Dockyards and Fleet Maintenance—will be supervised by the Fourth Sea Lord, who is already responsible for Supplies and Transport and will, in future, also assume responsibility, on behalf of the Controller, for the superintendence of the dockyards and the maintenance of the Fleet. His title is accordingly being changed to " Fourth Sea Lord and Vice-Controller."

This still leaves the Controller responsible for design and production of the ships and their equipment, including, of course, their weapons and aircraft, but the operation of the dockyards will be the responsibility of the Fourth Sea Lord. For example, it will be for the Controller to decide if a ship is to be built in a Royal Dockyard, while the Fourth Sea Lord will implement the decision and be responsible for the work carried out. Similarly, the latter will be responsible for Fleet maintenance as a whole. There can be no doubt that these reforms are long overdue. The Director Generals will relieve the Controller of the very heavy burden which falls on him at the present time and enable him to concentrate on his central and important task of design and development. The new system will also co-ordinate the work of the specialised divisions and enable decisions to be made without referring to the Controller at almost every point.

INSURANCE AGAINST NUCLEAR ACCIDENTS

Ministers seem to have been quite unusually active in fields of interest to engineers during the last few days ! We notice that three of the preceding articles discuss Ministerial activities, and this article refers to yet another. Last Monday, Sir Ian Horabin, replying on behalf of the Paymaster-General, to a question asked in the Commons, stated that the Government intends to introduce legislation to ensure, by a system of licensing and inspection, that nuclear reactors on land are made effectively subject to control in the interest of public safety. Up to date all nuclear reactors in this country, except a low-powered reactor being built at Aldermaston by Associated Electrical Industries, have been built for and operated by the Atomic Energy Authority, upon which there has been laid the duty of ensuring that no ionising radiations from its premises cause harm to persons or property. But the new nuclear power stations, building or authorised for construction in this country, will all come under the control of the electricity authorities. Furthermore, it seems to us by no means improbable that as the situation develops industry in this country may desire to construct in the not-distant future research reactors of more than one type for its own or other establishment's uses. In these circumstances, the Government is obviously acting wisely in thinking ahead as to the safeguards that should be applied. Sir Ian gave some general picture of the lines legislation is likely to follow. All owners of reactors will become liable to pay compensation for any damage that may be done, whether the accident causing the damage was or was not avoidable, except where it can be shown that the claimant was guilty of contributory negligence ; and to make certain that the liability can be met owners will be required to insure against accidents or hold available adequate liquid assets. A maximum liability in respect of any one incident of £5,000,000 is likely to be fixed. There is, of course, nothing very unusual about such legislation, which has been applied in the past to various other devices. It will be noted, however, that the legislation will relate only to land plants. Where a reactor is movable, as when it is installed in a ship or an aircraft, the situation is more complicated and, as Sir Ian pointed out, there are international aspects to be considered. In our view, indeed, even if the international aspect of the matter could be excluded, it is far too soon to lay down any such rules, as a system of licensing and inspection implies, to reactors in ships and aircraft. It will be better to await the construction of a commercial sea-going or air-going reactor.

The Engineer — 100 Years Ago (FEBRUARY 12, 1858)

" Prevention of Boiler Explosions "

" Early last year we printed Mr. Longridge's Annual Report to the Manchester Association for the Prevention of Boiler Explosions, for 1856, and we then took occasion to comment upon the details of that Report, and to make a few practical suggestions. We are glad to observe, in the Report for 1857, which we printed last week, that these suggestions appear to have exercised some influence in the deliberations of the Association. It appears that in 1857 there were 1,592 boilers under inspection, against 1,456 boilers in 1856, and 1,314 engines, representing a total of 46,186 nominal horse power. Of the number of boilers under inspection, 107 were found working in a dangerous condition, or 6¾ per cent, against 10 per cent in 1856. It is thus pleasing to remark a diminution in the proportion of dangerous boilers under inspection, and thence to infer the utility of the Association as a working body, for the promotion of the public safety. " We note, further, a slow increase of the working pressure of the boilers under inspection. The increase has taken place in pressures between 30 lb and 60 lb ; between 15 lb and 30 lb the proportion is stationary ; under 15 lb it is diminished ; above 60 lb it is also diminished. So that there appears to be a gradual settlement towards pressures of 40 lb to 60 lb. This is a statistical fact which could not have been arrived at but through the agency of a registering association. There is almost an entire collapse of high pressure practice above 75 lb, having been 2½ per cent in 1856, and only one-third per cent in 1857. The stationary world is not yet ripe for high pressure, notwithstanding the powerful persistent advocacy of Mr. Fairbairn in behalf of high pressure, at all times and places. Little will be done, we believe, in that way until the multitubular boiler becomes generally adopted, as we have no manner of doubt it must be."

Cost and Value of Automatic Train Control

By W. A. TUPLIN, D.Sc., M.I.Mech.E.

Bearing in mind the circumstances of some recent railway accidents in this country the author examines the human element in existing systems of so-called automatic train control. He discusses the main requirements of an automatic train control system based on the principle of "warning and acknowledgment" and thus demanding the active co-operation of the driver. He concludes that no system is really safe if it allows a train to continue running unless the driver gives positive acknowledgment on passing every signal that applies to him. Such a system would be a stage towards the future possibility of running driverless trains with fully automatic control.

CERTAIN railway accidents in recent years have drawn specific attention to the facts that :

(1) An engine driver may pass a distant signal without realising that he has done so (Harrow, October 8, 1952).

(2) An engine driver, believing a distant signal to have been at "clear," may be content to pass the two "stop" signals associated with it without seeing their aspects (Welwyn Garden City, January 7, 1957).

(3) An engine driver, even after a "caution" colour-light distant signal, may pass the following stop signal (even a colour-light signal) without knowing it (St. John's, December 4, 1957).

Condition (1) may be countered by a mechanism that warns a driver that he is about to pass a distant signal and begins to apply the brakes ; it need not indicate what the aspect of the signal is. The minimum provision that can offset conditions (2) and (3) is a device that fully applies the train brakes if a locomotive passes any stop signal without some positive acknowledgment of the fact by the driver.

The full brake application that any useful train stop must make, on passing a stop signal, is sometimes criticised because of the possibly dangerous consequences to the train. It would be interesting to have evidence of damage due to a full brake application, but in the meantime it is appropriate to point out that the risk, of whatever magnitude it may be, has long been accepted for continuously braked trains in which any coupling breakage will at once put the brakes full on. It is also tacitly accepted for loose-coupled trains inasmuch as, faced with the possibility of a collision, any driver of such a train will at once apply all the brake power at his command without pausing to assess the probability of breaking a coupling in the rebound from a quick "bunching" of the vehicles. A full brake application cannot be expected to be comfortable in any type of train, but it seems to be a tradition, rather than an established fact, that it is likely to be more dangerous than a collision.

Nevertheless, the possibility of trouble from the application of a train stop to a loose-coupled train is perhaps enough to warrant criticism of such application when a signal is overrun by a short distance merely because of a driver's error of judgment. This point is covered by using a train stop that a driver can avoid if he knows that he is passing the control point ; such a train stop works only in the case of an unconscious overrun and this is the really dangerous condition to be countered. That it is physically possible to produce devices that achieve these results is undoubted ; the real question is "Can the expense be justified ?"

The Western Region A.T.C. completely achieves the purpose of warning the driver of his approach to a distant signal. Reliance is not, however, officially placed on it for its original purpose of indicating the aspect of the signal, and if that particular purpose were to be abandoned, the other could be achieved by much simpler apparatus. If the lineside signal indication must be accepted as the true one, no additional one is necessary ; warning of approach to a distant signal is clearly valuable and if accompanied by a gradual brake application, is a safety device when the driver fails to locate the signal. Warning of immediate approach to a stop signal is valuable in fog, even though speed is low after the vital warning at the distant signal, because the driver's confidence that he cannot overrun the signal without knowing it, enables him to approach it briskly even in zero visibility. This advantage is smaller with colour-light signals than with less easily visible ones, but may nevertheless be appreciable.

Acknowledgment Principle

If the principle of requiring the driver to move a handle in acknowledgment of his passing every signal be accepted, very simple apparatus will suffice to cover (1) and (3), and also the condition of incapacitation of both enginemen by a footplate accident ; it will also cover (2) except for the case of a driver who acknowledges a signal at the right moment, but fails to act upon its instruction. This last condition is probably very rare indeed, but it could be covered at the cost of considerable complication of apparatus which, however, would then fail to deal with the probably no rarer case of incapacitation of the enginemen.

Drivers might object to physical acknowledgment of every signal on the ground of extra work merely to cover cases that experience shows to be extremely rare. The same argument may be used to question the ultimate value of cab signalling devices at all. With knowledge of the cost incurred by all accidents that might have been avoided by A.T.C. it is a matter of arithmetic to decide whether any proposed system applied throughout Great Britain is financially justifiable. In view of the rarity of such accidents in relation to all the places and all the trains that might have been associated with them, it would seem that only extremely simple apparatus can justify itself.

The financial value of A.T.C. in avoiding accidents is assessable reasonably well, but it is less easy to estimate its additional value in allowing trains to run faster in fog because of the confidence it gives to drivers. It seems possible that the loss of time in running slowly while locating signals in fog is even at present much less than that occupied in standing at signals discovered to be at "stop." Even with no assistance from A.T.C., many drivers will run at normal speed in fog where they are sure that fog signalmen are at work or where colour-light signals are in use. If that were true of all drivers, then audible indication of distant signal aspects would save no time at all, but warning of close approach to a stop signal (with a train stop in case of overrun) might save some time in fog. It is not certain, however, that reduction of approach time in fog means any real economy of time ; it may mean only that the train stands longer at the stop signal than it would have done without A.T.C. Moreover, it is not certain that complete elimination of delays due to fogs of normal frequency and duration would be of any appreciable financial advantage to the railway organisation. Punctuality regardless of weather conditions is an obvious ideal, but lateness (even serious lateness) in occasional foggy weather may mean little financial loss, unless it induces patrons to invent some less-affected alternative means of transport.

It is not entirely safe, therefore, to assume that any form of A.T.C. has any financial advantage beyond that of eliminating the costs of compensation for the accidents that it probably avoids. Before deciding whether there appears to be a case for it, one must decide to what proportion of the total track mileage and locomotive stock it should be applied. Accident records may (or may not) suggest that A.T.C. would be much more valuable on high-speed main lines than anywhere else and/or much more valuable on express passenger locomotives than on any others. But if any such discrimination is used in applying A.T.C., then enginemen are provided with an excuse (if not a reason) for failing to locate signals where either the locomotive or the track lacks the A.T.C. equipment. The only reliable procedure in considering the financial justification of A.T.C. is to assume its application to all running lines and all locomotives. If it fails to justify itself on this basis, then one is tempted to examine the logic of basing an estimate on partial application of A.T.C. At the other extreme one may ruefully reflect that if only one knew exactly which locomotives and which signals were going to be involved in signal overrunning accidents in the next twenty years, one would know exactly where to apply A.T.C. Whether it is possible to establish a logical mean between these extremes depends on the result of critical examination of all the relevant accident reports.

"Warning and Acknowledgment" A.T.C.

In any case, it is interesting to consider what simple form might be assumed by A.T.C. apparatus of what may be called "warning and acknowledgment" type. The simplest worthwhile A.T.C. system to cover (1), (3) and (very nearly) (2), would seem to be one that gives audible warning of the approach to every signal and fully applies the brakes on passing a point say 20 yards beyond a signal capable of a stop aspect unless the driver holds a handle in a particular position.

In the following, the essential features of an A.T.C. system are assumed to be :—

(*a*) The approach to every signal that the driver should observe must be accompanied by a warning audible by the driver and by anyone on the ground near to the warning point.

(*b*) The audible warning must be accompanied by establishment of a restricted

connection between train-pipe and atmosphere so as to initiate a brake application that gradually strengthens to the maximum, in time to stop the train within the average distance from distant signal to home signal.

(*c*) Conditions (*a*) and (*b*) must persist until the driver cancels them by a simple handle movement from a " running " position to a " cancel " position and back again.

(*d*) Movement of the acknowledgment handle away from the " running " position must produce the audible warning, must establish a restricted connection between train-pipe and atmosphere, and must disconnect the train-pipe from any apparatus capable of creating pressure or vacuum in it.

(*e*) Immediately after the driver's cab passes any running signal that is capable of giving a stop indication, and unless the acknowledgment handle is in the " cancel " position, the apparatus must make a full-brake application and must disconnect the train-pipe from any apparatus capable of creating pressure or vacuum in it.

(*f*) There must be no moving part in apparatus mounted on the track.

(*g*) Avoidance of use of electricity or magnetism.

(*h*) Avoidance of any apparatus accessible to the enginemen while the engine is running.

(*i*) The apparatus must neither require nor induce the driver to look anywhere but ahead.

To effect (*a*) and (*b*) apparatus under the cab of the locomotive might include a valve released (to fall " open ") by rise of a slider (or a rubber-tyred wheel) on meeting a track ramp on the approach to every signal. In the displaced position the valve would connect the train-pipe to atmosphere through a siren or whistle inaccessible to the driver, but audible by him and anyone on the track close by. Contact with a track ramp is sometimes criticised, but Great Western experience shows negligible wear of ramps and sliders even under spring loading of about 100 lb, which is necessary in the Great Western system to avoid rebound after the initial contact. In the system envisaged here, rebound would be unimportant and so light pressure would suffice.

To effect (*e*) the connection between ejectors (or air compressors) and the rest of the pneumatic system might include a length of glass tube, movably mounted under the cab of the locomotive, so that with the acknowledgment handle in the " running " position the tube would be broken by contact with a post fixed to the track close to every signal capable of a stop aspect. Movement of the acknowledgment handle from " running " to " cancel " would reset the warning valve, would establish a second connection between train-pipe and atmosphere through the siren, would disconnect the train-pipe from any pressure or vacuum-producing apparatus and would move the glass tube clear of the train stop posts. In running, the driver would cancel the warning of approach to a signal as soon as he saw its indication. He would also move the handle to the " cancel " position while passing the signal (other than a " distant " signal), whatever its aspect, in order to prevent the train stop from working. At high speed in low visibility, the driver's view of the signal might be too short for him to be sure that he could acknowledge it quickly enough. In such conditions he could hold the handle in the " cancel " position adopted to acknowledge the warning, until he had seen and passed the signal concerned, accepting an incipient brake application in the meantime. The train could not be restarted after being stopped by the apparatus until the broken glass tube had been replaced by a spare one, and this could be done only from track level and with the locomotive at rest.

The reason for making the warning sound audible from the track is to permit unobserved checks to be made on the working of the A.T.C. apparatus. The reason for (*d*) is to thwart any intention of the driver to save himself trouble by fastening the acknowledgment handle in the " cancel " position. The practice of deliberately putting safety devices out of action to suit personal convenience is not so rare that it can be ignored. The reason for (*h*) is to thwart any other application of misplaced ingenuity.

In this scheme, the driver is warned of his approach to every signal and must make an acknowledging movement if the train is not to be brought to rest. He is given no indication of the aspect of the signal, but he is helped to locate it, and if he fails to do so, the train will be stopped before the next signal. At the cost of very considerable additional apparatus he can be informed of the aspect of the signal and the train need not be stopped even if he fails to acknowledge a " clear " signal. Is this necessarily an advantage ? It makes life easier for the driver, but perhaps too easy.

On the Western Region it is at present possible for a train to run non-stop for 100 miles if all the signals are " off " and the driver need not see any of them. If the driver's failure to see any signals is due to zero visibility, the ability nevertheless to run at full speed betokens a very good signalling system. If, on the other hand, the driver does not see the signals because he does not trouble to look out, the system seems to be bad inasmuch as it condones such irresponsibility. This contradiction emphasises the suggestion that if mechanical aid is given to the driver in locating a signal, he should be required to give in return some proof that he has in fact seen it. This principle would stop all traffic in zero visibility, whereas the Western Region A.T.C. (for example) may appear to permit trains to run so long as signals are " off." In actual fact, Western Region practice does not officially permit this in spite of its A.T.C., as drivers are required to observe either the fixed signals or those of the corresponding fog signalmen. Hence, the system now proposed would not be inferior to the Western Region system in thick fog. It would be superior in that it would compel drivers to see all the relevant signals instead of asking them to do so and giving them apparatus that makes observation of the distant signal superfluous.

Any driver who objected to the need for acknowledging the passing of home and starting signals after seeing the distant signal at clear would thereby suggest that he accepted the principle that if the distant is " off " all the associated stop signals are " off." The rarity of any exception to this principle (as, for example, when a signalman reverses home and starting signals in an emergency after a train has passed a clear distant signal) naturally inclines drivers to accept the principle. Nevertheless, no driver is really justified in entering a section without seeing a " clear " aspect of the signal that controls access to it.

With the A.T.C. scheme contemplated here, a driver would need :

(α) To see every signal affecting him and to acknowledge it ; or

(β) To acknowledge a signal affecting him from accurate knowledge of its position without actually seeing it ; or

(γ) To hold the acknowledgment handle in the " cancel " position from his approach to the home signal at a block point until well past the outermost starting signal.

Adoption of (β) means adoption of the principle that if the distant is " off " the other signals are off and requires close familiarity with details of the local geography. Adoption of (γ), by continuous sounding of the A.T.C. warning signal advertises to everyone in the neighbourhood that the driver is shirking his responsibility for seeing signals, it accepts a brake application of severity determined by the details of the apparatus and the time taken to run from the home warning point to clearing the outermost starter, and it prevents the driver from receiving any audible warning of his approach to any signal. Hence, the A.T.C. would impose an additional duty that would give more confidence to the conscientious driver and more trouble to the irresponsible one. It would not absolutely defeat the irresponsible one nor the one (if any there be) who is determined to go on no matter what the signals may say.

Costs

It is already being realised that the driver's duties on long runs on electric or diesel-electric locomotives are more likely to be productive of boredom (and even somnolence) than on steam locomotives, because of reduced discomfort and of greatly reduced need for concern about the locomotive as a machine. Consequently, it may be positively advantageous to require the driver's interest with signals to be something more alert and active than only seeing them. For an A.T.C. system that gives warning of approach to every signal, the total number of ramps would be about three times as great as for a system acting only with distant signals. The same remark would apply to any A.T.C. system applied with colour-light signals, every one of which may be either a distant signal or a stop signal according to its aspect. There are many alternatives in the mechanical details of a scheme such as this and the main object in design would be to achieve the minimum total cost of production, installation and maintenance consistent with reliability. For some 20,000 drivers' cabs and 40,000 signal locations even a capital cost of only £50 each means £3,000,000, while interest, maintenance and depreciation could mean £300,000 per annum. It is doubtful whether A.T.C. in Great Britain could recover such expenditure as this.

It may be asked whether, instead of considering automatic train control as normally understood, it would not be more appropriate to devise means of running trains without drivers at all. This is a future possibility and it underlines the need for economy in any A.T.C. system that may be widely adopted as an interim measure. No system is really safe if it allows a train to continue running without a positive acknowledgment by the driver on passing every signal that applies to him. Neither colour-light signalling (e.g. St. John's) nor the warning type of A.T.C. (e.g., Dagenham, January 30, 1958) is any guarantee against running past stop signals in thick fog.

TABULAR SUMMARY OF CIVIL ENGINEERING CONTRACTS.—On page 40 of the *Tabular Summary of Civil Engineering Contracts*, published with THE ENGINEER of December 20 last, there is an entry describing the Cromwell Road Extension (A4), for which the Middlesex County Council is the supervising authority. We are informed that the part of this work which is being constructed by the Alderton Construction Company, Ltd., is the Chiswick flyover, at a value of £820,000. Further, the flyover is being built directly for the Ministry of Transport and Civil Aviation, and the consulting engineer who is supervising the work is Mr. Harry Brompton, M.I.C.E.

Satellite Rocket Problems

By PROFESSOR A. D. BAXTER, M.Eng., M.I.Mech.E., F.R.Ae.S., F.Inst.Pet.*

CONSIDERABLE excitement has accompanied the success and failure of recent satellite rocket launchings and the haze of contradictory reports has resulted in many engineers finding more than a little difficulty in assessing what these triumphs and disasters amount to in a technical sense. Rockets have been known and used for centuries, but the modern high performance unit is only possible because of the great strides in engineering design and development which have been taken during the last fifteen years.

Some of the landmarks are indicated in Table I, either by the height or range achieved or by the more satisfactory parameter of maximum speed attained. This latter criterion gives an indication of the potential height or range which can be achieved and its relation to the technical development of the rocket will be shown later. It will be noted that the quite high speed (measured by aircraft standards) of 1 mile per second only provided a range of 200 miles, but that range increases more rapidly than speed, and five times this speed gives orbital trajectories. Still greater velocities would give the rocket elliptical orbits of ever increasing eccentricity until at a velocity of 7 miles per second the eccentricity is infinite and the ellipse has opened to a parabola. Thus the rocket never returns and has reached the "escape" velocity which would enable it to voyage into outer space. Still greater velocities cause the vehicle to move along hyperbolic paths which approach a straight line as the velocity approaches infinity. These paths are illustrated in Fig. 1.

TABLE I—*Development in Long Range Rockets*

Year	Rocket	Performance			Remarks
		Height, miles	Range, miles	Maximum velocity, miles/second	
1942	"V.2"	—	—	—	German—first successful flight of long-range rocket
1944	"V.2"	—	200	1·0	German—payload 2000 lb
1945	"A.9/A.10"	—	3100	1·75	German—proposed two stage
1946	"V.2"	114	—	1·0	American
1949	"V.2/Wac Corporal"	250	—	1·45	American—two stage
1951	"Viking"	136	—	—	American—improved "V.2"
1954	"Viking"	158	—	—	American—improved "V.2"
1955	"Vanguard"		Satellite orbit		American—three stage; development programme announced
1957	"Sputnik"	250	—	5·0	Russian—satellite; payload 186 lb

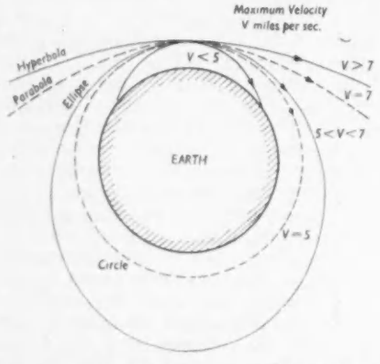


Fig. 1—Influence of velocity on rocket vehicle flight paths

* Chief Executive, Rocket Division, de Havilland Engine Company, Ltd.

Design Requirements

It is clear that the performance of a rocket depends upon the maximum velocity it can achieve. If V is this velocity, it can be shown that

$$V = v_j \log_e M/m$$

where

v_j = rocket exhaust jet velocity.
M = weight of rocket at take-off.
m = weight of rocket at end of motor operation.

The ratio M/m is referred to as the mass ratio and both it and the jet velocity should be large. Fig. 2 shows the relationship graphically and indicates that large mass ratios are essential even if exceptional jet velocities can be obtained. Present-day motors can produce exhaust jets approaching 8000ft per second and it seems unlikely that chemical propellants will ever be able to provide jets of more than 13,000ft per second. There are, of course, other less conventional propellant possibilities, but these are still very much in the future. Mass ratio is mainly an engineering problem on how to pack the greatest possible weight of propellant into the lightest possible rocket vehicle. At the present the mass ratio of a single stage rocket is of the order of 7 : 1, while the theoretical requirements to reach orbital velocity is about 28 : 1.

In practice a still greater mass ratio is required because the rocket has to overcome gravity in climbing to altitudes where there is no atmospheric drag and also drag must be overcome on the climb. These effects can be allowed for by providing the rocket with a higher potential velocity. The atmospheric drag can be balanced by the energy required to produce an additional rocket velocity of about 0·15 mile per second and similarly gravity can be overcome by an additional 0·75 mile per second. Thus the satellite rocket needs a potential velocity of nearly 6 miles per second and the actual mass ratio required, as shown on Fig. 2, will be about 50 : 1. Similarly to escape altogether from the earth's gravitational field will require a rocket with a velocity of 8 miles per second and a mass ratio of 200 : 1.

Mass Ratio

It is impossible to foresee improvement in rocket design that will permit such large mass ratios as are required for satellite vehicles being achieved in a single stage. Fortunately, the principle of staging, that is, carrying one rocket as the payload of another, overcomes the problem. The payload rocket will be accelerated up to a speed corresponding to the mass ratio of the composite rocket before it begins to thrust. At this point it discards the empty structure of the first stage and can then increase its velocity by an amount corresponding to its mass ratio. The final velocity will be the sum of the velocity increment added by each rocket stage. Thus, if a single-stage rocket of 4 : 1 mass ratio produces a velocity of 2 miles per second, the addition of a second stage, also of 4 : 1 mass ratio, will add a further 2 miles per second, giving a total of 4 miles per second. The addition of a similar third stage would give a final velocity of 6 miles per second.

The drawback to this system is that the final payload becomes very small in relation to the initial weight of the whole assembly at take-off. It is only a fraction of the empty weight of the rocket, which includes its structure, tanks, motor and control gear. Thus a payload of 1 ton would be associated with a structure of 2 tons or more. The empty weight would therefore be 3 tons and the weight at beginning of operation 12 tons. This, in turn, would be a payload associated with the previous stage rocket structure of 24 tons. The first-stage rocket would have a payload of 36 tons, an empty weight of 108 tons and an initial weight of 432 tons.

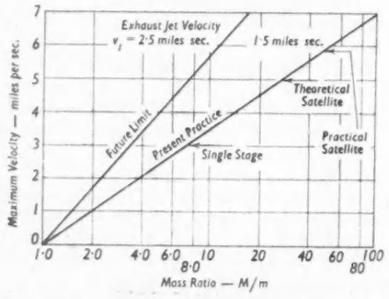


Fig. 2—Effect of exhaust jet velocity and mass ratio on maximum flight velocity

It will be observed that in this calculation, a payload amounting to 33 per cent of the empty weight of each stage has been assumed. If this had been reduced to 25 per cent, the effect would have been to increase the take-off weight from 432 tons to 1024 tons. At the other end of the operation, it means that the useful load is only one-third or one-quarter of the actual mass placed into an orbit. Thus, the Russian claim to have launched a satellite of ½ ton, may not be so large a step forward as appeared at first sight.

The important point which emerges clearly is that rocket structure and other components must be kept to the minimum possible weight. This is shown in Fig. 3 for a two-stage rocket, each stage having a mass ratio of 7 : 1 and the payload starting as 20 per cent of the second-stage empty weight. A reduction of 10 per cent in structure weight, for example,

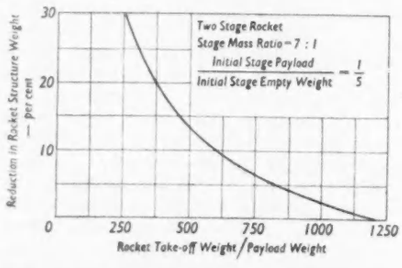


Fig. 3—Effect of reduction in rocket structure on size of two stage rocket

halves the size of rocket required for a fixed payload and final velocity.

Weight reductions have been achieved in both structure and motor by a combination of detail refinement in design, new design techniques and new materials. Normal stressing factors are drastically reduced and in many parts operating stresses reach 80 per cent or more of the ultimate strength. As an example, satellite rockets are not subjected to very severe transverse accelerations and consequently the lateral stiffness can be greatly reduced. At the same time, it must be adequate to avoid aeroelastic and control system feed-back effects. As another example, the weight of propellant tanks can be reduced without danger of rupture to a point where they will collapse under their own weight, but they can be made adequately stiff by pressurising rather like balloons. The pressurising may be done with helium gas instead of nitrogen. For a large rocket this saving in weight is quite appreciable—of the order of $\frac{1}{2}$ ton in a 100-ton rocket. Again, care must be taken to avoid the trapping of any residual propellants at the end of the motor thrust period. Such propellants are not only wasted as far as providing thrust is concerned, but also reduce the effective mass ratio. They might occur as a result of poor feed system layout or malfunctioning of the mixture ratio control.

In the motor itself similar refinements of detail design and stressing are necessary to keep down dead weight. Considerable thought has been given, for example, to the optimum combustion chamber pressure and nozzle expansion ratio. High values of both give a higher value of jet velocity, but also involve additional weight. The use of single or multiple engines for providing the large take-off thrusts required is another point which is still controversial. According to the square/cube law, a number of small engines is lighter than one large one, but practically there must be some minimum where this law breaks down. It has been suggested that this occurs with rockets requiring about 60,000 lb thrust, but American motors of more than twice this thrust have been produced. Combustion chambers have been greatly reduced in weight by the development of a multi-tube combustion chamber such as that shown in Fig. 4 (*a*). Normally, a chamber has an inner and outer wall with an annular cooling space between as in Fig. 4 (*b*), but with large thrust motors the chamber diameter becomes large and the chamber wall thickness increases correspondingly. Apart from an inevitable increase in weight, this leads to serious heat transfer difficulties. With the new design, each tube can be of quite light gauge, because the main bursting strength is supplied by external wire windings and heat transfer through the thin walls is adequate to maintain them at a relatively low temperature. At the same time, this may introduce a new limitation, especially if higher performance is sought by increasing the combustion temperature. The actual heat flow through the walls of the improved design is increased considerably, but the capacity of the cooling propellant to remove the heat is limited by its boiling point.

This leads to consideration of still further developments ; similarly, other examples of ingenious design and their reaction on the rest of the rocket can be multiplied throughout the vehicle. Without describing these in detail it will be sufficient to re-emphasise that a major portion of the design effort must be concentrated on reducing weight. Every pound saved on dead weight lightens the take-off weight by something between 7 lb and 50 lb.

Exhaust Jet Velocity

It was pointed out earlier that there is a limit on the possible increases in jet velocity and, in fact, quite severe conditions will be met in achieving any improvement at all. This can best be appreciated by examining the factors involved. They are included in the equation below :

$$v_j = \sqrt{2g \cdot \frac{\gamma}{\gamma - 1} \cdot \frac{KTc}{M} \cdot \left[1 - \left(\frac{Pe}{Pc}\right)^{\frac{\gamma - 1}{\gamma}}\right]}$$

where the main variables are Tc and M, the gas combustion temperature and molecular weight, a property of the propellants, and Pc and Pe, the combustion and exhaust pressures, which can be controlled by the designer.

The gas is produced by chemical reaction and, in general, propellants will be selected which give high values of Tc and low values

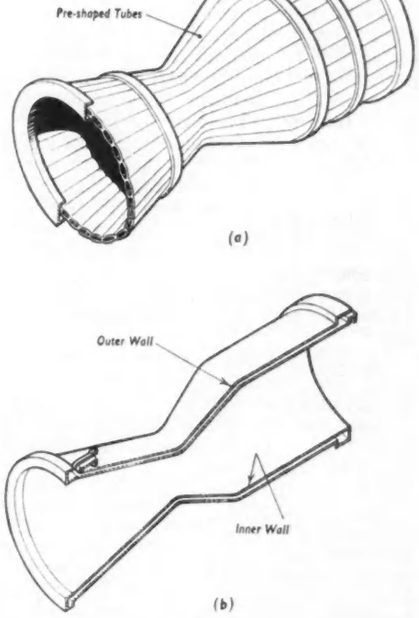


Fig. 4—(*a*) Multi-tube lightweight construction, (*b*) Conventional rocket combustion chamber

of M. Current propellants give gas temperatures up to 3200 deg. Cent. and molecular weights around 25. More advanced propellants are known and these might produce gas at 4500 deg. Cent., but with relatively higher molecular weight, so that the overall improvement would be much less. Incidentally, it must be remembered that the effect on velocity varies only as the square root of Tc/M. Also, to contain gases in combustion chambers at such temperatures will, as mentioned above, require an improvement in heat transfer technique of a major order. Most rocket motors are only just capable of dealing with present-day temperatures without failure.

Bearing in mind these limitations, some of the possible propellant combinations can be examined. These may be either in liquid or solid form. The earliest rockets used solid propellant, such as black powder and, later, cordite or similar mixtures. Liquid propellants only came into favour at the end of the 1939–45 war, when their better performance was found necessary for the guided weapons being developed. More recently the solid came back into the picture, due partly to improvements in intrinsic performance and partly to developments in charge design and lightweight casings. Nevertheless, they suffer certain inherent disadvantages which should leave the liquid propellants as the final choice.

Table II lists a few of the large number of

Table II—*Some High-Performance Propellants*

Propellant	Gas temperature, deg. K.	Jet velocity, v_j ft/second	Relative density
Solid :			
Black powder ...	—	2,000	1·5
Cordite	2,500	7,200	1·6
Future	3,200	8,000	1·6
Liquid :			
Oxygen/kerosene ...	3,430	8,000	0·98
Oxygen / hydrazine	3,090	8,550	1·06
Oxygen / diborane	3,740	9,650	0·77
Oxygen / hydrogen	2,570	11,050	0·24
Ozone/hydrogen ...	2,630	12,000	0·23
Ozone/beryllium ...	—	13,600	1·77
Fluorine/hydrazine	4,500	9,600	1·30
Fluorine / hydrogen	4,740	11,750	0·29

propellant combinations which might, theoretically, be used. In the solid field, the best that can be foreseen is not greater than existing liquids can provide and to reach such values the gas temperature will be very high for chambers in which the propellant cannot be used as a coolant, as in the liquid types.

The present high-performance liquid propellants are based on liquid oxygen as the oxidant. The other two standard oxidants are hydrogen peroxide and nitric acid. Both these have certain attractions, but where maximum jet velocity is the criterion, they have to take second place. Other chemicals which might be considered are liquid ozone, liquid fluorine monoxide or chlorine trifluoride. These are some of the so-called "exotic" oxidants, although they are not necessarily oxidising agents. They can be any fluids which have a high exothermic reactivity with the fuels and so produce the essential high-temperature gases. Similarly, the present conventional fuels are hydrocarbons, but there are a number of less common compounds which increase the performance considerably. These usually contain a large proportion of hydrogen as this ensures a low molecular weight of the product gas. Almost the best of all is liquid hydrogen and it also has the advantage of a relatively low gas temperature. It is only exceeded in performance by the metal beryllium.

It is often not appreciated that many metals are quite good fuels, but unfortunately the oxide formed usually has a high latent heat and much of the energy of the reaction is locked up in evaporating the oxide. Only the low-molecular-weight metals need be considered and these only give marginal improvement over liquid fuels except in the cases of boron and beryllium. To use them presents considerable technical difficulty, particularly in feeding the metal to the chamber and in ensuring adequate heat transfer for cooling. One possibility for injection is to place the metal in a liquid fuel as a suspension or slurry. The problem of maintaining uniform distribution in the liquid and chemical stability in the tanks is then very great, to say nothing of the pumping difficulties and the abrasive action of the powder on pumps, injection orifices and control valves.

Metal powder, even in very fine particles, tends to form an oxide coating over the surface when it burns, leaving a central nucleus unburnt. This will represent a loss in performance which may more than offset

any gain. Furthermore, if some of the oxides leave the nozzle in solid form, the exhaust will be very smoky.

Although liquid hydrogen appears so outstanding, it has one major disadvantage apart from its low boiling point. It is that its density is very low and consequently a very large capacity tank is required compared with that for a more conventional propellant giving the same total thrust. Not only does this affect the drag of a rocket adversely, but also the empty weight, particularly in view of the insulation problem. It is almost certain that at some stage in space rocket development, hydrogen will be used as fuel, but at the present time advances are more likely to be successful using hydrazine (N_2H_4) or ammonia (NH_3) as these give better overall propellant relative densities as indicated in Table II. In this connection it may be remarked that the solid propellants score heavily.

The more advanced oxidants are not attractive, apart from their potential performance, as they are either toxic, unsuitable or incompatible with most engineering materials. Pure ozone is extremely shock sensitive and will explode easily ; similarly, liquid fluorine needs to be produced on the rocket firing site to avoid transport problems and the difficulties of controlling the toxic gas which constantly boils off.

In the motor itself, these advanced propellants raise problems of sealing, strength and corrosion. Most sealing materials become brittle at the low temperatures of liquid oxygen and other similar fluids, the design of joints must allow for thermal distortions and shock conditions where extreme changes in temperature occur, and lubrication of pump bearings and the operation of valves becomes difficult.

Reliability

Because the rocket vehicle and its propulsion system are designed with the barest minimum of safety margin, there are a number of risks of failure occurring before or during the launching. Apart from the risk of mechanical failure of a component, there are various functioning sequences which must operate correctly. For example, the pumps must be driven at the appropriate speed and propellant injection and ignition be correctly phased. It is probable that the ignition is the most critical event in the launching programme. Adequate energy must be supplied to the propellants as they enter the combustion chamber to ensure ignition without a delay of more than a few milliseconds. Otherwise there is the risk of propellant accumulation and a " hard " start in which the sudden ignition of a large quantity of propellant gives a high shock pressure with resultant damage. This ignition difficulty may be greater in the late stages of the multi-stage rocket when pressure and temperature conditions are lower than at ground level.

Generally, multi-stage rockets will have a much lower reliability than a single-stage unit ; for example, if the chances of success are 90 per cent for a single-stage unit, the three-stage vehicle would have only a $0{\cdot}9\times0{\cdot}9\times0{\cdot}9=73$ per cent chance of success. The figure of 90 per cent used may well be on the high side for experimental rockets of the size involved in satellite launchings. This would be the stage reliability if the number of components involved was only 120 and the reliability of each one was 99·9 per cent.

It is clear, therefore, that the failure of the " Vanguard " rockets was not unlikely, and also that the Russian success points either to a large slice of luck or else to a very highly developed vehicle.

Theory of Regenerative Machine Tool Chatter*

By S. A. TOBIAS, D.Sc., Ph.D.,† and PROFESSOR W. FISHWICK, Ph.D.‡

(No. II—*Concluded from page 203, February 7*)

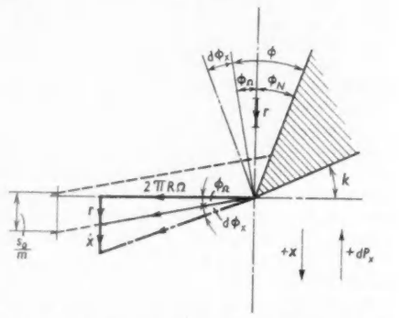
The Experimental Determination of the Factor k_1

Before we turn to the explanation of the use of the stability chart it will be convenient to discuss the physical significance and the method of determination of the parameters which affect its shape. The factors k_s and k_Ω appear in the work of previous investigators and so they do not need any further discussion. (k_Ω does not enter at all in the case of type A chatter.) Thus, we shall be concerned only with k_1 and $K=k_s-k_1$, which are entirely new and which may as a result be viewed with suspicion.

According to equation (7) the incremental thrust dP_x is required for the production of an alteration of the cutting conditions, specified by ds, dr and $d\Omega=0$ ($dv=0$). This force consists of two parts. The first part $k_1 . ds$ will be required for the removal of the additional chip thickness and the second part Kdr/Ω is necessary for the alteration of the feed rate. The term Kdr/Ω represents the difference between the total thrust increment $k_s dr/\Omega$, calculated as though dr was a steady state increase, and the actual thrust increment $k_1 dr/\Omega$, calculated for an independent variation of the feed rate by dr. This term can be interpreted as being essentially due to two physical effects, the penetration effect and the rake angle variation effect both dependent on the instantaneous feed rate.

Consider a cutting tool which is about to come into contact with the work piece. Before cutting can commence a finite pressure between the cutting edge and the material is required. To begin with, this pressure causes an elastic deformation at the point of contact, and after it has reached a certain level the work piece material commences to flow and the tool can penetrate. When the tool is cutting and it is required to leave its steady motion and penetrate deeper into the material, an additional thrust is necessary besides the thrust used for the removal of the increased chip thickness. This additional thrust is used for breaking the surface and to overcome the resistance due to a change of the angle of flow with respect to the cutting edge. The conditions arising are obviously of great complexity and are not yet fully clarified. However, it can be seen intuitively that the additional thrust is approximately proportional to dr and inversely proportional to Ω.[1]

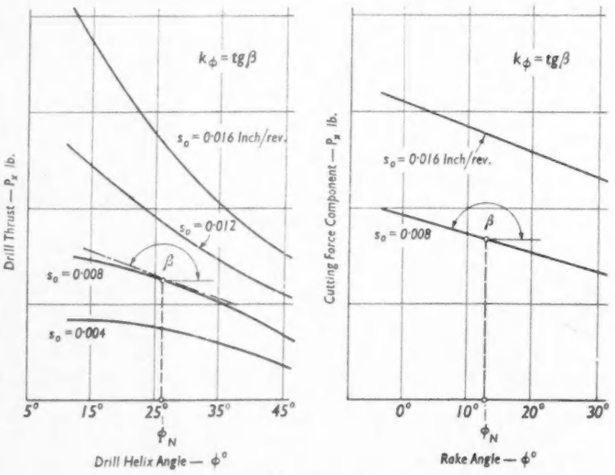
While the penetration effect causes an increase of the thrust for an increase of r, the rake angle effect results in its reduction. Fig. 9 shows a cross section of the cutting tool



A variation of the feed rate r by dr results in a rake angle variation of $d\phi=dr/2\pi R\Omega$.

Fig. 9—Variation of the rake angle

of one of the cases shown in Fig. 1(*a*) to 1(*c*) in a plane which passes through the cutting velocity and the direction x. As can be seen from the figure, an increase of r by dr results in an increase of the effective rake angle Φ by $d\Phi=dr/2\pi R\Omega$, where R is a radius from the centre of rotation. This causes a change of the thrust increment by $k_\Phi . dr/2\pi R\Omega$, where $k_\Phi<0$. k_Φ is determined by machining with tools of various rake angles (Φ_N) under otherwise identical conditions and by plotting the thrust P_x as a function of Φ_N. The types of curves obtained for drilling are shown on Fig. 10(*a*) and those for turning on Fig. 10(*b*).



(*a*) drill thrust as a function of the helix angle; (*b*) cutting thrust component P_x as a function of the rake angle for turning.

Fig. 10—Determination of the factor k_ϕ

The determination of k_Φ from these curves is obvious from the figures and it is clear that $k_\Phi<0$.

Whether $K>0$ or $K<0$ depends on which of the two effects is the dominant. In the case of drilling into solid material the penetration effect is the dominant owing to the chisel edge which offers great resistance to an increase of the feed rate. The same is true for grinding since in that case one cannot speak properly of a rake angle and so in

* This article is an extended version of a paper read at the "Second Colloquium for Machine Tool Research and Design" (2.FoKoMa), held at the Technische Hochschule, München, 1955.

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‡ Professor of Electrical Engineering, University College, Swansea.

both cases $K>0$. When drilling up a predrilled hole the chisel edge is absent and according to the analysis given by the authors[1] we should find $K<0$. The same analysis ought to apply also to face milling and turning and so they should also have a $K<0$ or, at least, very small.

K and, to some extent, k_1 are dependent on a great many factors which affect the thrust. Among these it is worth while to mention the condition of the cutting edge (sharp or blunt), its geometry (shape and cutting angles, relief angle), the frictional conditions (cutting fluids), the work piece material, &c. It is one of the main advantages of the present theory that these factors do not appear explicitly and as a result the mathematical procedure is relatively simple. Their effect on the stability of machining is investigated by analysing their effect on the numerical value of k_s and k_1.

k_1 and so K can, in principle, be determined by both static and dynamic tests. In the case of static tests the experimental conditions are devised in such a way that the chip thickness s can be varied independently of the feed rate r. When shaping the chip thickness can be varied while keeping the rate of penetration constant ($r=0$). By preforming the upper surface of the chip to be removed to vary in, say, a linear way and measuring P_x, we obtain $P_x(s)$ in a single test (for $r=0$), and from this curve k_1 is determined by graphical differentiation. The same idea can be adopted to a lathe tool by shaping the end of a tube suitably and measuring P_x during one revolution. This experiment can be carried out for various feed rates and can also be adopted to grinding.

The dynamic determination of k_1 is most conveniently based on equation (9). The experimental conditions must be devised in such a way that both λ and Ω can be varied in small steps. λ is adjusted for chatter to occur in some rotational speed band. After that Ω is varied till the system is on the threshold of stability—that is, small oscillations of uniform amplitudes occur and so $\alpha=0$. For this case equation (9) can be written

$$dP_x=k_1\left(1-\mu\cos\frac{2\pi}{m}\frac{\omega}{\Omega}\right)m\ddot{x}+\left(k_1\frac{\mu m}{\omega}\sin\frac{2\pi}{m}\frac{\omega}{\Omega}+\frac{k_s-k_1}{\Omega}\right)\frac{dx}{dt} \quad . \quad . \quad . \quad . \quad . \quad (27)$$

Assuming that k_s has previously been determined and so, since μ, m and $\Omega=1/T$ are given, by measuring dP_x, ω, x and dx/dt the factor k_1 is easily calculated. Care must be taken that the experimental conditions correspond to the threshold of stability. If the conditions correspond to an unstable point of the stability chart the amplitudes will be large and non-linear effects enter which will affect the reliability of the measurements. If the adjustment of threshold of stability conditions proves to be impracticable, then records of the actual building up or decaying of the vibration amplitudes can also be used. These will yield α and in conjunction with equation (9) finally k_1 and so K.

The Use of the Stability Chart

It will be appreciated that one of the major advantages of the present theory lies in the fact that the conditions under which chatter can exist can be surveyed at a glance and that steps to be taken for its avoidance can be decided without taking recourse to tedious calculations of stability conditions. From the point of view of the application of the stability chart it is not even necessary to be familiar or to understand the underlying mathematical theory or the physical phenomena which produce chatter. In this sense the stability charts presented in this paper are similar to other charts used extensively in the design office or the workshop.

In general, the present theory recommends that when designing or using machine tools the dynamic stiffness λ for each mode between work piece and cutting edges should be kept as high as possible. This results in a raising of the Q_{ω_0} line in Fig. 5 to Fig. 7, as a result of which the area of the unconditionally stable region is enlarged. An identical result is achieved by decreasing k_1, which is dependent on the tool form and the work piece material. Similarly, K is also determined by these factors and an attempt to make K a large positive value is worth while, since this ensures freedom from chatter at low rotational speed. In those cases where the damping of the system is to some extent under control, large damping (low values of Q) obviously should be striven for since this also increases the stability of the system.

Consider now the application of the stability chart to a design problem. Since the natural frequencies and their corresponding damping Q of similar types of machines vary but little, the Q's of the various modes can initially be assumed to be known from previous tests. Let the various natural frequencies of such a machine be ω_{01}, ω_{02}, &c., and the corresponding Q's be Q_1, Q_2, &c. The designer is now given a series of stability charts corresponding to the type of machining under consideration ($K>0$ or $K<0$) which have been calculated for various values of the parameters k_1/λ and K/λ. From these he selects one chart for which the $Q_e=Q_1$, $=Q_2$, &c., lines (parallel to the $m\Omega/\omega_0$ axis in the charts) fall entirely in the unshaded region. He thus has fixed a value for k_1/λ. From the maximum required cut he can now find the maximum value of k_1, which is likely to occur and so he obtains λ, i.e. the required dynamic stiffness between work piece and cutting tool. This procedure may be modified in the case of special machine tools which have only one rotational speed and for which the most suitable speed is easily found from the stability chart. When designing entirely new machines the natural frequencies can be found by building and testing a model and using the results in conjunction with the stability chart for the determination of the most economical designs.

The machine tool user is advised by the stability chart in the proper choice of machining conditions (speeds, feeds, suitable tools and work piece materials and suitable foundations,[2] &c.). Let us assume that Fig. 7 represents the stability chart of a certain machining job which he is about to carry out. From previous tests he may know that in the particular machine a mode of vibration with ω_0 natural frequency and, say, $Q_e=14\cdot5$ is liable to cause chatter. The $Q_e=14\cdot5$ line in the stability chart intersects the shaded area (unstable regions) between $1\cdot84>m\Omega/\omega_0>1\cdot15$ and $0\cdot67>m\Omega/\omega_0>0\cdot56$. This means that if he wishes to avoid chatter the rotational speed must not fall in the speed bands $1\cdot84$ $(\omega_0/m)>\Omega>1\cdot15$ (ω_0/m) and $0\cdot67$ $(\omega_0/m)>\Omega>0\cdot56$ (ω_0/m). He can thus find the most suitable machining conditions. This procedure may be too cumbersome for most practical cases, but it will be worth while when the machine will carry out the same operation for a long period (for instance, in the case of transfer machines), since by the elimination of chatter tool life is greatly increased.

When buying a new machine the customer is able to compare the dynamic performance of competitive designs by simply comparing their stability charts determined for some standard machining conditions. Stability charts can also be used as a comparative measure for different designs of tools. When testing various tools on the same machine Q_e and λ can be assumed to be kept constant. As a result the stability of each tool and the test machine will depend solely on k_1 and K. Thus, by determining k_1 and K for certain standardised conditions (machines, work piece material, &c.), the tool designer is able to give a direct measure of the chatter behaviour of his tools. He will be expected to design tools which have a small k_1 and large positive K values.

It should be added that the stability charts can also be used for the investigation of some special problems, for instance, the effect of flexible supports on the chatter behaviour of machine tool. A paper dealing with this problem is about to be published.[2]

From these remarks it will be clear that the problem of machine tool chatter will be solved economically only by a collaboration of the machine tool designer, the tool designer, the metallurgist and the machine tool user. There is no doubt that by designing machines of exceptionally high stiffness chatter can be eliminated by the sole efforts of the machine tool designer. The essential question is, however, whether this course is in fact economical and whether machines designed in this way will ever become competitive as long as the tools and the materials used are liable to chatter and insufficient care is taken by the user concerning the foundation. Since chatter is due to the interaction of a large number of factors, it is only to be expected that its economic solution will be achieved only by a collaboration of all concerned.

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University Scholarships

THE firm of Guest, Keen and Nettlefolds, Ltd., is offering three university scholarships each year to boys who might not otherwise be able to accept a place at a university. This scheme is in line with those recently instituted by other companies and engineering organisations and is designed to help boys whose parents' incomes are such that their state scholarships or local education authority grants are drastically reduced by the operation of a means test. The firm will pay the students' fees to the university or college in the normal way, but the students will rank as employees of the company and their maintenance and costs will be paid as a salary, subject only to deductions of income tax and National Health Insurance.

The students, of whom two each year must be engineers, will be selected by a special board. G.K.N. students will work during their long vacations either with group companies in this country or with recognised companies on the Continent, and will be paid an additional salary. The time spent on this approved workshop training will be deducted from the two years required for the full graduate apprenticeship, which will be served with the company. Application forms may be obtained from the Group Personnel Officer, Guest, Keen and Nettlefolds, Ltd., Shell-Mex House, Strand, W.C.2. The closing date for this year's applications is April 30.

Measuring the Structural Behaviour of Hungry Horse Dam

By JOE T. RICHARDSON*

Articles have been published in the American Section of THE ENGINEER *during 1955 discussing projects of the Bureau of Reclamation. The discussion on the Hungry Horse Dam,[1] a variable thickness arch dam located in Montana, is of particular current interest and points out the many important phases relative to this structure and its power plant. However, one important phase that will be of interest to the engineering profession as a whole and of special interest to persons connected with the structural analysis of arch dams[2] deserves more detailed attention. This phase is the extensive array of instruments placed in the mass concrete of the structure for determining the in-service behaviour of the dam, as well as the specialised installations of instruments that were provided to determine the short-time behaviour of certain elements of the dam.*

THE Bureau of Reclamation, during the past twenty-five years beginning with the construction of Hoover Dam, has included in all of its major concrete dams, structures such as Hoover Dam, Grand Coulee Dam, Shasta Dam, Canyon Ferry Dam, and Hungry Horse Dam, instruments to determine, through systematic observations, the changing strain and other quantities that occur within the structure. These quantities, when combined with laboratory-determined factors that govern temperature, creep of concrete under sustained load, autogenous growth, Poisson's ratio effect and other effects, furnish results in terms of stress measured within the structure. Both arch dams and gravity dams have been investigated by embedded instruments. The measurements in the dam structures are made using strain meters, stress meters, joint meters, crack detectors, hydrostatic pressure gauges, all of which are elastic-wire-type instruments, and resistance thermometers, which are resistance-type instruments. Electrical cables connect the instruments to reading stations in the galleries of the dam where readings are made, using portable Wheatstone bridge test sets. Whenever feasible, the results from these measurements are correlated with external precise survey and plumb line measurements that are made simultaneously. Provisions for a number of kinds of measurements have been made in the structural behaviour programme for Hungry Horse Dam.

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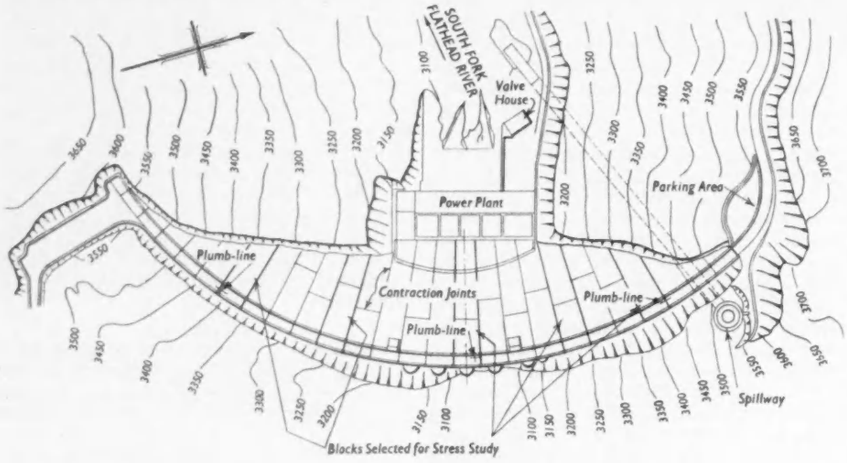
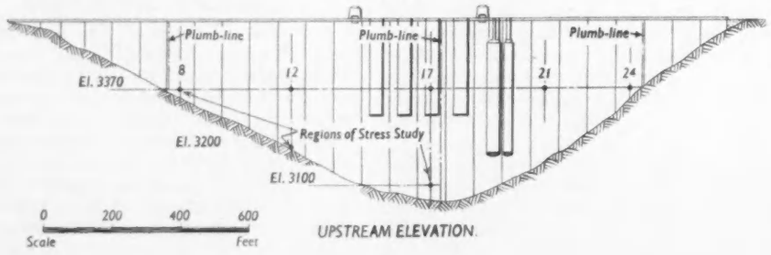
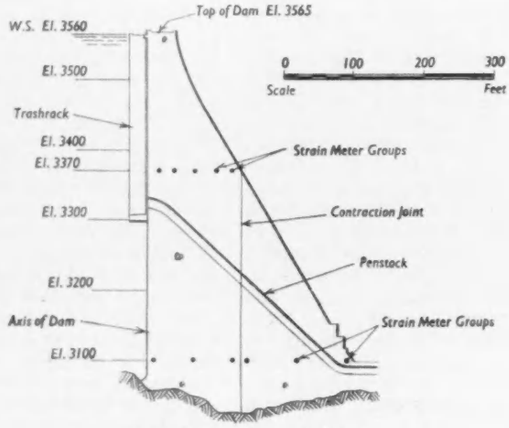
Fig. 2—Strain meter group at base of maximum section



PLAN.



UPSTREAM ELEVATION.



MAXIMUM SECTION C.L. BLOCK 17.

Fig. 1—Locations of strain meter groups

The installation in Hungry Horse Dam includes a total of 681 instruments embedded in the structure. The instrumentation comprises 508 strain meters, 12 stress meters, 80 joint meters, 22 reinforcement meters, 6 hydrostatic pressure meters, and 53 resistance thermometers. The majority of instruments are strain meters, which were provided to determine the distribution of stress on radial lines through the dam at seven principal locations, as shown on Fig. 1.

The principal locations were selected as representative of general areas of maximum stress anticipated within the structure. The principal locations furnish the stress distribution for one complete arch of the dam at an elevation where stresses are not affected by the longitudinal contraction joint, and furnish the stress distribution at the bases of two cantilevers. The cantilever bases are directly below locations of stress determination in the arch. In the arch the stresses were obtained by groups of strain meters at several points on each of five radial lines. At the bases of the cantilevers the stresses were likewise obtained at several points on radial lines by groups of strain meters. Where the radial lines of instruments cross the longitudinal contraction joint, strain meter groups were duplicated 5ft to either side of the joint. By this expedient peculiarities in stress due to the joint could be studied.

Two kinds of strain meter arrays were used in the dam. At the base of the maximum cantilever the strain meters were placed as individual meters in groups of ten meters

Fig. 3—Strain meter group, showing instruments assembled to holding spider

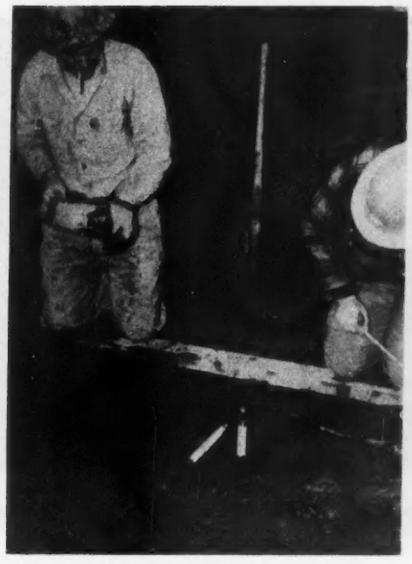


Fig. 4—Pair of strain meters for determining volume change in mass concrete

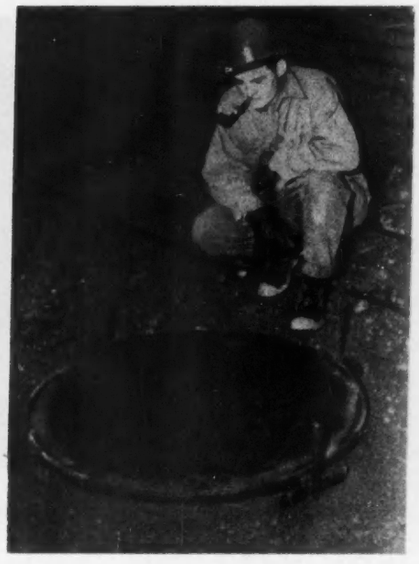


Fig. 5—Steel cover plate in place over pair of embedded strain meters

each, the meters being oriented as shown in Fig. 2. At all other locations in the dam the strain meters were placed in clusters of twelve meters. Eleven meters are supported by a holding spider, which orientates the meters as shown in Fig. 3, and the twelfth meter is placed as a single vertical instrument along with the cluster.

To investigate the variation of stress near a free surface clusters of strain meters in groups of three were provided at three locations in the dam near the faces of the structure.

Included with each principal location of strain meter groups were a pair of strain meters embedded in the mass concrete to provide a record of pure volume change in the concrete. These paired strain meters were placed approximately in the centre of the section and close to the top of the construction lifts. Over each pair of meters was placed a $\frac{1}{16}$in thick circular steel cover plate, 40in in diameter, and supported by its 2in rim above the top of the concrete. Fig. 4 shows the pair of strain meters in place in the mass concrete, and Fig. 5 shows the steel cover plate. Thus, an artificial free surface is included within the mass of the dam. One strain meter normal (vertical) to the free surface measures only the variations in volume change of the concrete due to temperature, moisture change, and possible autogenous growth. The second strain meter of the pair which is placed parallel (horizontal) to the free surface, was provided to evaluate any strains due to horizontal stress that might induce error in the vertical measurements through the effect of Poisson's ratio.

Pairs of stress meters were included with strain meter groups at the base of the maximum section to determine vertical stress and to serve as an additional check of strain meter results. Fig. 6 shows a typical stress meter installation.

Joint meters were installed across both the radial and longitudinal contraction joints to measure the beginning and extent of joint opening. Fig. 7 shows a typical joint meter installation. The instruments across radial joints are located on the joints directly to either side and at the same elevations of the strain meter groups. On the longitudinal joints, the instruments are located at several elevations to determine the joint opening at these elevations as load was applied to the dam.

Reinforcement meters are small strain meters encased in tubing of a cross sectional area equivalent to the reinforcing steel. These instruments replaced sections of the reinforcing steel of several elements within the dam. These instruments determine stress variation in the particular element of interest. The elements investigated comprised reinforcing steel around penstocks and galleries, and vertical reinforcing steel of a trashrack structure. Strain meters were attached directly to the outer surface of the steel lining of a penstock to determine stress in the lining. Fig. 8 shows two typical reinforcement meters in place in steel surrounding a penstock. In this figure there is also shown a strain meter attached directly to the penstock steel.

Six hydrostatic pressure meters were installed near the base of a maximum section of the dam, at varying distances from the upstream face, to determine the development of hydrostatic pressures within the concrete of the dam.

Resistance thermometers were installed on a 50ft by 50ft grid through a maximum section of the dam to determine completely the temperature distribution of the section. The factor of temperature in an arch dam is of great importance, since the volume change caused by temperature changes imposes one of the major loads on an arch dam.

In addition to the measurements made by instruments embedded in the dam, the

Fig. 6—Stress meters prior to embedment

Fig. 7—Typical joint meter installation

Figs. 8 and 9—(Left) Reinforcement meters installed in reinforcing steel at bottom of penstock. Note protection covers over strain meter attached to penstock steel. (Right) Deflection measuring station, micrometer-microscope apparatus and plumb-line

deflection of the structure is charted by micrometer-microscope measurements made on three plumb lines contained in wells that extend from the top of the structure to near the foundation. One plumb line, 500ft in length, is located in the maximum section near the centre of the structure and contains deflection measuring stations at five elevations. The plumb lines located near the quarter points of the dam, are 188ft and 157ft in length, and contain measurements stations at their lower extremities. Fig. 9 shows the micrometer-microscope apparatus being used at a deflection measuring station.

Processing of strain meter measurement data from the seven principal locations in the dam are completed. Plotted stress results for Hungry Horse Dam[3, 4] are included in reports which have been prepared.

Measurements from all instruments are continuing and at some future date the computations will be extended to include results of stress that occurred during several periods of reservoir operation. Fig. 10 shows the resulting normal vertical stresses and the horizontal arch stresses on all lines of measurement as indicated for the termination date of the analysis. Processing of data obtained from the specialised installations is now being expedited and results will be available at an early date.

The development of the method used for processing the large volume of data obtained from the measuring instruments has an interesting background. Similar computations that had been performed earlier for other dams[5] had been conducted by engineers using longhand transcription methods and desk calculators. This practice had proved unsatisfactory due to the large volume of data that required processing, as well as the tedious nature of the work. With the construction of Hungry Horse Dam and its extensive instrumentation, the task of deriving stress at progressive intervals using conventional methods of computing to combine data from laboratory tests for associated creep, temperature and growth for the periods of record, was recognised to be an extremely complex and time consuming problem. The designers of Hungry Horse Dam had expressed the desire to know the pattern of stress developing at the base of the maximum section of the dam, along with the progressing construction.

Solution to the problem was made possible by the expedient of punched cards and high-speed digital computers.[6] In the beginning of the machine computing operations many difficulties arose owing to differences between the earlier hand method of computation and an applicable machine method that would give comparable results.

The programme for stress investigation was developed in such a manner that through the expedient of machine computations the determination of actual stress conditions at the base of the crown cantilever was made possible within approximately thirty days after field recordings had been made.

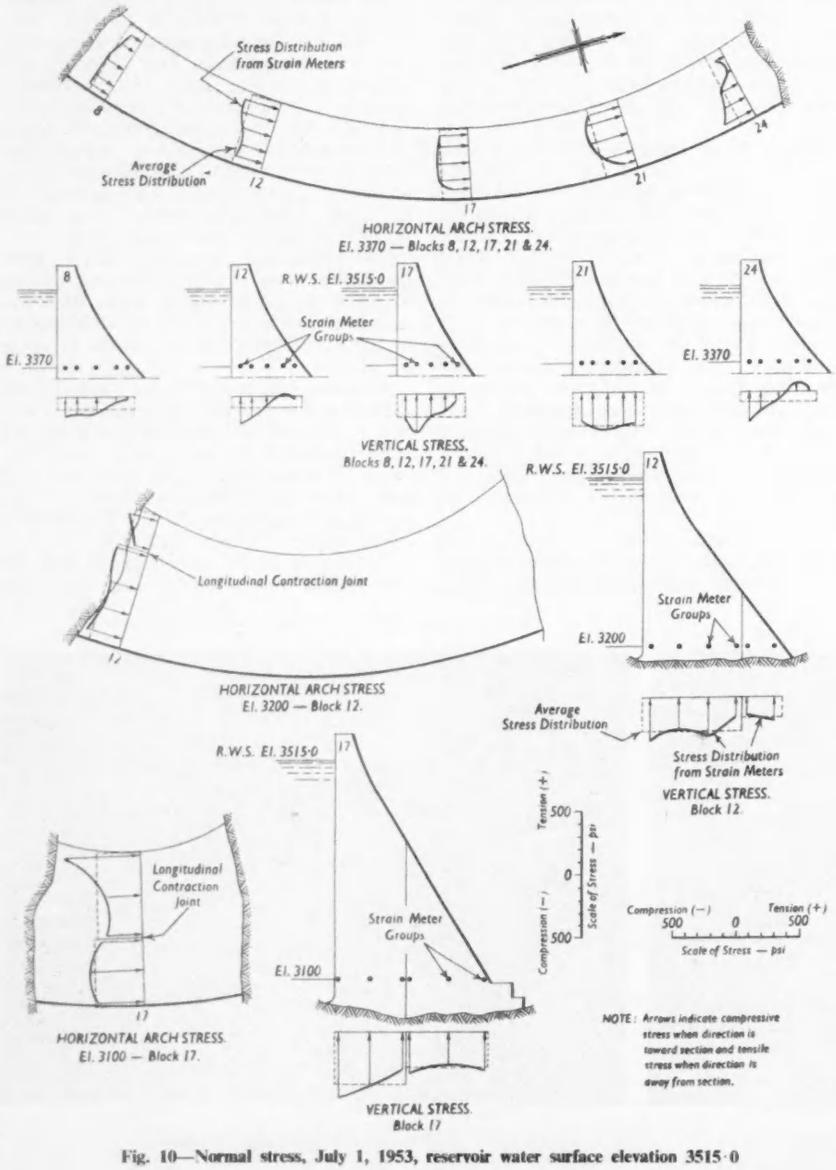


Fig. 10—Normal stress, July 1, 1953, reservoir water surface elevation 3515·0

The results from the in-service stress behaviour studies of Hungry Horse Dam are anticipated to be of great value not only to provide the stress behaviour for that particular dam, but as companion information that when combined with similar results from other dams will serve as criteria to furnish the design engineer with a means to narrow the gap that exists between results of design studies and the results of in-service operating conditions for dams. These criteria may also make possible, through factors introduced into design studies, the modification or revision of design conditions and assumptions in order that they will be more realistic and equitable to actual in-service conditions in dams than have been possible in design studies of the past, particularly with respect to stress due to the effects of temperature variations.

While analytical studies for any arch dam design include ample allowances to assure safe operation of the structure during a period of maximum stressed conditions, these same studies do not necessarily guarantee the structure will behave stresswise in the manner anticipated by the design or that actual in-service stresses will be equivalent to those derived in the design study. These differences are accountable through the unlike conditions of design and operation, since conditions and factors that must be established for a design are usually based on the maximum loading conditions for the structure. These conditions are not often duplicated during the operation of a structure and thus only in a very rare instance will they be equal.

Many factors, such as creep of concrete under sustained load, stress due to triaxial loading, varying temperature effect throughout a structure, modulus of elasticity of abutment rock, and autogenous growth of some concretes, all contribute to stress as obtained through structural behaviour measurements. These factors are automatically included in the stress results of the study of in-service operation of a structure, but their introduction into a design study may become so complex that to provide for their inclusion in the design study becomes almost impossible.

Unit stress as derived by the two methods of analysis is of a differing nature. Stress in design, results from the combination of weights, moments and other factors, and stress from measurement results from observed strain. The former is expressed as average unit stress, and the latter is actual unit stress. The two can be expected to differ at the points of measurement in an elastic medium as concrete. Stress distributions for sections of dam structures are unlike due to the methods of study. The total stress for sections will be the same, regardless of the method of stress derivation used, provided, of course, that loading is the same.

In combination with results from similar measurements at other structures, the information will further serve as criteria to aid modification of design to ensure that a structure will behave as intended by the design. In addition, there will be the economy resulting from the efficient use of materials brought about through the application of these criteria.

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Digital Computers and the Design of Nuclear Reactors

By J. HOWLETT, B.Sc., Ph.D., A.M.I.E.E.*

In a paper discussed at an ordinary meeting of the Institution of Electrical Engineers in London on February 4, Dr. Howlett reviewed the main computational problems involved in the design of a nuclear power reactor. He outlined the two main computational methods available : first, the Monte Carlo method (so called because it uses random numbers in a statistical calculation) which is suitable for tackling neutron-transport problems ; the second consists of analytical methods based on the transport equation. The author examined the general use of digital computers for such problems and considered three examples in more detail. Finally he discussed the performance of computers likely to be needed for such work in the future. Abstracts from the paper are given here.

TO see how and where in a design study the computing problems arise, let us consider the main steps in the process, assuming that the reactor is intended to drive an electrical power station.

First, a decision must be taken, based on very broad economic and scientific arguments, on the electrical output required and the type of reactor to be built. Thus, if 100MW of electrical energy is the aim, the reactor will have to deliver about 400MW of heat ; if it is to be a natural or slightly enriched uranium thermal reactor (as is most likely for several years to come) the fuel rating will be about 4MW per ton and the charge will therefore be about 100 tons. The moderating ratio will have to lie in the range from about 1 : 1 to 5 : 1, so the total weight of moderator will lie between about 100 and 500 tons ; the shape is not likely to differ greatly from a right cylinder, so the dimensions can be quickly settled within reasonable limits.

General engineering and metallurgical considerations will determine a range for the working temperature, and the known problems of pumping—the power required and possible corrosion effects—will settle general questions on the circulation of the coolant, which may be the moderator also, and will thus provide some criteria for the design of the heat exchanger.

The main programme of nuclear calculations can now start. The aim will be to find the dependence of the critical mass of the core on the moderating ratio, enrichment of fuel, temperature and dimensions, all these quantities being allowed to vary over the ranges suggested by the preceding general arguments. The calculations will give in each case the flux distribution and hence the fission rate (which determines the power level) and the conversion factor for the build-up of fuels such as plutonium 239 or uranium 233 if this is a relevant consideration. These criticality calculations will use such integral nuclear properties of the core design as thermal utilisation factor, resonance escape probability and slowing down and diffusion lengths, which must themselves be calculated from design details and basic nuclear data.

Heat-transfer calculations will show how the supply of energy to the electrical station varies with the reactor coolant circulation rate and outlet temperature (and pressure if it is a gas) ; these will probably have to be done for several sets of design details of the heat exchanger. Much of this depends upon empirical laws.

If these calculations have been made in sufficient detail, there will be enough information to settle within closer limits the essential details of the design on economic grounds, balancing the value of the electrical output and any fuel breeding against the cost of the reactor, fuel charge, heat exchanger and generating equipment.

With the narrowed ranges for the design parameters, further calculations will be needed to give :

(*a*) The kinetics of the reactor, i.e. the response to movements of the control elements, particularly when starting up or shutting down ; the possibility of dangerous surges in power or temperature must be investigated.

(*b*) Long-term changes in reactivity due to the accumulation of fission-product poisons, to fuel breeding and to burn-up of the fuel charge ; the results here will enable a fuel-cycling schedule to be worked out.

(*c*) The shielding requirements ; there are worth-while economies to be achieved by avoiding excessive amounts of shielding beyond what is needed for safety.

The results of this last group of calculations will probably lead to a re-examination of the earlier optimisation, and possibly to a need for more criticality calculations ; after a few repetitions of the whole process it should be possible to settle definite values for the design parameters.

Almost all the separate calculations here are complicated and of large scale ; it is not possible to work through such a programme in a reasonable time, and in the detail required, without powerful computing machinery. It would be possible to build a special machine to perform any one of the calculations, as has, in fact, been done,[1–3] but because they are so different mathematically, any organisation which has to to carry out complete studies will need to have—or at least to have access to—a fast general purpose digital computer. The field is an ideal one for the application of these machines : the amount of computation to be done is very large, so the benefits of high speed are great ; there is a wide variety of problems, so that machine's flexibility is exploited ; much of the work has to be done to high numerical precision, so good use is made of the ability to carry many figures in the calculation ; and all the calculations have to be repeated many times with different values for the parameters, so a good return is obtained for the effort put into the development of the machine programmes. In this connection there is one very important advantage of machine computation : if a large survey has to be made with real urgency, and if it is important enough to command exclusive use of the machine, then it can be carried through simply by continuous running, all the staff available taking turns to operate the machine.

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Without a machine a design team must prune its demands very drastically, both by making do with a much less detailed survey than it would like to have and by using methods known to be of lower accuracy than others which, though preferable, would use more computing time, such as using diffusion theory approximations when these are not justified or treating as spherically symmetrical a system for which a finite cylinder is a much better representation. This question of approximations certainly arises in computer applications, but less sharply and at a less elementary level. Of course, reactors have been designed successfully without the aid of fast computers, but these were essentially non-commercial plants where economic questions hardly arose ; for full-scale industrial use reactors must be designed with close regard to these questions, and they cannot be settled without extensive and detailed calculations.

Methods Available

Of the essential computational problems of reactor design just listed the largest and most characteristic are those concerning the nuclear properties, which involve a study of the neutron population. This is necessarily a difficult mathematical problem ; a neutron is described by seven co-ordinates : three for space, two for angle (for the direction of motion), speed (or energy) and time ; the important events in its life are collisions with nuclei, the results of which are described by complicated laws deduced from fundamental nuclear-physics experiments. The methods available for attacking these problems of neutron transport can be grouped as follows :

(*a*) Exact formulation in terms of the laws which describe the movements of individual neutrons ; these state the probabilities of various events, such as collision, absorption, fission. The method is statistical and, because of its use of random numbers in the calculation, is usually known as the Monte Carlo method.

(*b*) Idealised formulation, regarding the neutron population as continuous and setting up a conservation equation as in hydrodynamics ; this is an integro-differential equation, known as the Boltzmann transport equation. In certain circumstances, e.g. in systems large compared with the neutron mean free path (and therefore in much of the work on thermal reactors), it can be reduced to the partial differential equations of the diffusion-theory approximation. From either of these equations one can proceed in either of two ways :

(i) Attempts at formal analytical solution, e.g. by expansion in series or by integral (e.g. Laplace) transforms. An example is the spherical harmonics method[4] for solving the transport equation ; a standard process for solving the diffusion equations in a cylindrical system is to expand in a series of Bessel functions.

(ii) Direct numerical solution, without recourse to analysis ; all differential coefficients are replaced by differences and all integrals by sums, so that the problem is reduced to that of solving a system of algebraic equations. The paper shows how this is applied to the diffusion equations ; Carlson[4,5] has developed a corresponding method for solution of the transport equation.

The application of a fast automatic computer to a mathematical problem can be approached in two ways. One can either attempt a solution by formal mathematical analysis, carrying this as far as possible and bringing the machine to evaluate the expressions obtained, much as one would use hand-computing methods ; or one can develop a method which is numerical from the start and which is designed with the machine's properties in mind. This is paralleled above in the division into methods (i) on the one hand and (*a*) and (ii) on the other. The analytical method has the advantage that the work is kept general until a late stage and numbers are inserted only when analysis can go no further ; the final computations usually go through quickly even though they may seem very heavy for hand computation ; thus a large parameter survey can be made in a reasonable time. The disadvantages in reactor work are all consequences of the complications of the mathematics. First, only simple geometries can be dealt with ; one-dimensional systems are reasonably tractable (e.g. spheres or infinite cylinders), two-dimensional systems are much more difficult (e.g. finite cylinders with symmetry about the axis) and three-dimensional systems are quite unmanageable. Secondly, only simple energy-dependence can be allowed ; most of the analytical treatments have been made with at most two energy groups, and some work has been done with simple functional energy dependence, leading to heavy algebra,[6] but no treatment of detailed energy dependence seems possible. Finally, almost all such methods are approximate in the sense that they depend upon expansions into series with a limited, usually very small, number of terms retained ; any attempt to improve on this is likely to be defeated by the weight of the algebra. Thus, in the spherical harmonics method the standard practice is to go as far as the P_3 term ; the next approximation, taking P_5, requires much more labour and it is doubtful whether anyone has ever gone further. All this is not to be taken to imply that these analytical methods are of no value ; on the contrary, they provide an exceedingly valuable way of surveying a wide field quite quickly as a first approximation, and so narrowing the ranges over which more accurate methods have to be used. But the advent of fast automatic machines has reduced the incentive to press this treatment further, and it is unlikely that there will be any important new developments ; thus Davison's book[7] can probably be taken as the final summing-up of the analytical theory of neutron transport.

The purely numerical methods ((*a*) and (ii) above) are much more in the spirit of automatic computers and could not be used effectively until such machines had been developed ; both are likely to involve large—probably very large—numbers of arithmetical operations, but most of these will be arranged in fairly simple patterns repeated many times, which is the ideal situation for computer programming.

With method (ii), since analytical difficulties are avoided, more complicated situations can be considered, such as genuinely two-dimensional systems and detailed variations of nuclear properties with energy ; but the time required to achieve a solution will increase with the complication of the problem, so there are practical limits to the applications. For example, three-dimensional problems can, in principle, be solved by these methods, but are, in fact, still unmanageable, simply because even the fastest of present-day machines is too slow. In place of the analytical difficulties, one is now faced with questions of convergence and stability of iterative processes and of the effects of truncation errors (i.e. of the approximations introduced when differential coefficients or integrals are replaced by finite differences or sums) ; these are important and difficult questions—more exacting, in fact, than the technical complications of heavy algebra—and give plenty of scope for mathematical study.[8–11] The effects of truncation errors can usually be investigated empirically by making exploratory calculations (on the machine, of course) with different intervals in the differencing process, or different forms of approximation ; slowness of convergence and instability (i.e. the computed solution running away from the true solution, owing to build-up of rounding errors) are usually made obvious by the progress of the calculation but may be very difficult to overcome. An unstable computing process is, of course, useless ; an improvement in the rate of convergence may, by greatly reducing the time taken to find an acceptable solution, make all the difference between an academic mathematical process and a practical computational method. The effect of truncation errors is seen very clearly in one important reactor calculation ; an attempt to integrate the equations for the reactor kinetics[12] by a step-by-step method using the standard Runge-Kutta process[13] may prove impractical because of the need to use extremely small steps, and therefore very long machine runs, even though the neutron densities are changing very slowly with time ; this is due to the fact that the method is equivalent to taking at each step a fixed number (four is usual) of terms of an expansion for the solution in powers of the interval, and the numerical values may be such that this is a poor approximation unless the interval is very small. The only remedy is to use a method having a different mathematical basis, such as one of the Fox-Goodwin processes (see Reference 14, which also refers to this particular difficulty).

The Monte Carlo method is the most general possible and can, in principle, be used to solve any reactor problem, however complex. The essential features are the tracing, by calculations using random numbers, of the life histories of samples from the neutron population and the inferring from these of the properties of the population as a whole. Because it abandons analysis completely, even in the formulation of the problem, this method provides the best hope for dealing with complicated geometry or energy dependence. It also provides the only means of accurate formulation of some problems ; for example, the conditions at the surface of a hole inside a reactor can be expressed only approximately in diffusion theory, and in terms of transport theory are complicated and very difficult to use, but the Monte Carlo method uses directly the simple physical fact that a neutron emerging into a hole will travel straight across at constant speed. The drawback to the method is that, being statistical, it gives results in the form, " the probability is P that the parameter k lies between a and b," and for good accuracy, i.e. the location of the number required between narrow limits with high probability, a very large amount of computation may be required. However, considerable gains can be made by proper design of the calculation (which can be regarded as a theoretical experiment), and recent developments in statistical techniques can give large improvements in the efficiency.[15–17]

[The author then considered three examples : first, the calculation of the thermal utilisation factor for a lattice, by the spherical harmonics method ; second, the direct numerical solution of the two-group diffusion equations for a cylindrical

reactor ; and, third, the resonance escape probability for a lattice, calculated by the Monte Carlo method.]

Machine Developments in the Future

The examples [given in the paper], which are typical of the analytical, direct numerical and Monte Carlo approaches to reactor calculations, indicate the extent to which machines of various standards of performance meet the demands made on them. The Mark I* computer, with a speed of about 500 arithmetical operations per second, is quite adequate for even a complicated algebraic process but is about at its limit in the solution of the two-dimensional criticality problem : machine runs of two hours and more per solution are uncomfortably long, especially when a failure near the end may vitiate all the preceding work ; also such long times make it difficult to run through a parameter survey (say of 10 to 20 solutions) in any reasonable time unless the work is given high priority. The Mercury and the 704 computers, with speeds about ten to twenty times that of the Mark I*, are adequate for this problem, the latter gaining an extra advantage from its larger fast store. Similar remarks apply to the Monte Carlo calculation.

However, it is certain that as reactor design standards advance, engineers will want more elaborate and extensive calculations which will be beyond the scope of even the best of present-day machines. The criticality calculation for a genuinely three-dimensional system is an example. In the two-dimensional programme described the number of flux values stored is between 10^3 and 2×10^3 and the number of arithmetical operations performed is about 10^6. The three-dimensional calculation would require more flux values, more operations at each mesh point in the course of each iteration and more iterations, because the convergence would be slower ; making reasonable estimates for these effects, one is led to the conclusions that the number of fluxes to be stored is of the order of 10^5 and the number of operations at least 10^8, even if one uses only a two-group approximation. Since such calculations would be wanted in batches, either for parameter surveys or in theoretical studies of the life history of a proposed reactor, a running time of about 15 min (say 10^3 sec) would be desirable ; thus the machine speed would have to be at least 10^5 operations per second, i.e. at most 10 microsec per operation. Furthermore, to avoid serious loss of overall computing speed in transfers between the fast and backing stores, it would be necessary to have a fast store able to hold most of the number field, i.e. for about 10^5 numbers. It is open to question whether one would, in fact, use simple diffusion theory for a calculation on this scale ; it is not unlikely that a Monte Carlo method would be used, to permit a more realistic representation of the reactor structure. But what is certain is that the standards set by the needs of the diffusion theory calculation will not be higher than those for more accurate methods, so we may take these as the minimum to be aimed at.

It is known that there are several projects under way in America for building machines of at least this standard. The two about which most information is available are the "Larc" and the "Stretch," both sponsored by the United States Atomic Energy Commission. The first will run at about 10^5 operations per second with fast storage for some multiple of 10^4 numbers—figures of 50,000 to 60,000 have been quoted—and is due for completion this year. The corresponding figures for the other are 10^6 operations per second and 10^5 numbers at least, this machine being due for completion in 1960. The name "Stretch" was given to bring out the fact that this speed is approaching the limit which can be reached with known or foreseeable components ; for instance, a time of 1 microsec for a complete multiplication requires that the circuit elements (transistors) shall operate at 100 Mc/s to 200 Mc/s, and at this frequency the time taken for the pulses to travel round the computer is beginning to limit its physical size. It is thus possible that this order of performance may represent the end-point of computer development, apart from such arrangements as parallel operation of arithmetic units or even complete machines to give increased effective speed ; if this proves to be so, the development will have been taken from start to finish in the short time of about twenty-five years, and undoubtedly the needs of the nuclear-energy world will have provided an important part of the stimulus.

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Locomotive Performance

By E. C. POULTNEY, O.B.E.*

The comprehensive experiments carried out with the standard class "8" locomotive No. 71000 on the Western Region plant at Swindon and others on the W.R. and L.M. Region lines have already formed the subject of an informative review by O. S. Nock, B.Sc., published in "The Engineer" of August 23 and 30. The object of the present article is to supplement the information already given by making more extended reference to the performance of the boiler and others of the same general type which have previously been the subject of exhaustive trials made under the auspices of the Locomotive Testing Committee, British Railways, and also the cylinder performance resulting from the use of poppet valves and rotary cam operating gear. The latter will probably be of interest for the reason that these tests are the most complete yet made with a locomotive equipped with a valve gear of this kind by British Railways and, as such, will enable comparison being made between poppet and piston valves for the steam distribution in locomotive cylinders.

IN addition to the B.R. class "8" boiler, the performance of three others of the same general type and of similar dimensions will be considered. The four boilers are as under :

(1) B.R. class "8," Test Report No. 15, 1957.

(2) B.R. class "7," Test Report No. 5, 1953.

(3) L.N.E.R. class "V2," Test Report No. 8, 1953.

(4) S.R. "M.N." class, Test Report No. 10, 1954.

The principal dimensions of these boilers are given in the accompanying Table I, and a few notes on their design are as follow.

Considering in the first place the class "8" boiler, it will be seen from the general dimensions given that this and the B.R. class "7" boiler are very similar. In fact, the only difference of note is the size of the grate. It has an area of 48·6 square feet, in the later design, as compared with 42 square feet for the earlier one. In consequence, there is some increase in the size of the

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TABLE I—*Locomotive Boilers : Principal Dimensions and Ratios*

Boiler No.	1	2	3	4
Locomotive :				
Type	4-6-2	4-6-2	2-6-2	4-6-2
Class	B.R. Class "8"	B.R. Class "7"	L.N.E.R. Class "V2"	S.R. "MN" class
Working steam pressure, pounds per square inch	250	250	220	280
Heating surfaces, square feet :				
Tubes and flues	2264	2264	2216	2175·9
Firebox	226	210	215	275·0
Total evaporative	2490	2474	2431	2450·9
Superheater	691	718	679·6	662·0
Combined	3181	3192	3110·6	3112·9
Grate area, square feet	48·6	42·0	41·25	48·5
Firebox volume, cubic feet	296·4	274·2	254·8	300·6
Free gas area through tubes and flues, square feet	6·8	6·8	6·23	6·09
Air space through grate, square feet	21·0	14·8	15·0	24·25
Ratios :				
Firebox :				
Heating surface/grate area	4·65	5·0	5·2	5·67
Volume/grate area	6·1	6·53	6·17	6·19
Free gas area through tubes and flues, per cent of grate area	14·0	16·2	15·1	12·6
Air space through grate, per cent of grate area	43·2	37·0	36·55	50·0
Free gas area through superheater flues, per cent of total	60·8	60·9	57·9	54·8
Firebox heating surface, per cent of evaporative heating surface	9·07	8·3	8·85	12·0
Superheater heating surface, per cent of combined heating surface	21·7	22·5	21·8	21·3
Combined heating surface/grate area	65·5	76·0	75·0	65·55

S.R. "Merchant Navy" class. Firebox heating surface includes syphons. Superheater surface outside surfaces of elements, 1¼in outside diameter, 10 S.W.G. thick.

firebox, which provides 226 square feet of heating surface as against 210 square feet. The respective volumes are 296·4 and 274·2 cubic feet. Both these boilers are of the Belpaire type, and the inner fireboxes have combustion chambers. The tubes, superheater flues, and elements are the same in number and are of the same dimensions for each of these boilers. The class " V2 " boiler has a firebox of the round top, radially stayed pattern in line with standard practice at Doncaster, and is used for locomotives built originally in 1936 for mixed traffic services on the former L.N.E.R. main line. These engines have three cylinders and are of the 2–6–2 type. It will be noticed that there is a general similarity between this boiler and the B.R. class " 7 " standard design of 1951. The S.R. boiler for the the three-cylinder " Merchant Navy " class express locomotives has a firebox of the Belpaire type and, though of much the same size as the other three boilers, differs in two important respects in that it has an inner firebox of steel, fitted with two thermic syphons, which add materially to the firebox heating surfaces. The firebox is of the combustion chamber design and it will be noted that the grate area is of the same size as for the new B.R. class " 8 " locomotive.

The coal used for the boiler tests under review was of the same general quality—Blidworth—a grade 2B fuel having calorific values B.Th.U. per pound, as under :

Boiler	C.V. " as fired "	C.V. " dry "
Class " 8 "	12,850	13,980
Class " 7 "	12,600	13,710
Class " V2 "	12,680	13,470
Class " M.N. "	12,887	13,846

The principal tests made with the B.R. class " 8 " locomotive were carried out with a higher quality of coal, known as South Kirkby, a grade of fuel having a higher heating value of 13,550 B.Th.U. per pound " as fired." A few trials were, however, made with Blidworth coal, and it is these that are the subject of this article for the reason that Blidworth coal only was used for the tests made with the L.N.E.R. " V2 " locomotive.

Boiler Efficiencies

The relation between the overall thermal efficiencies of the four boilers, as disclosed by the tests, is shown by the graph, Fig. 1.

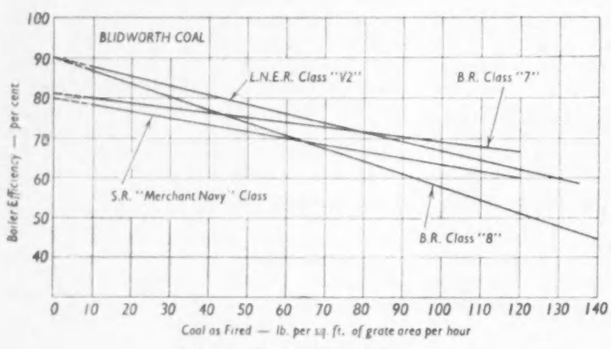


Fig. 1—Test train at Aulnoye

In harmony with normal practice, firing rates in terms of coal, pounds fired per square foot of grate area per hour as taken as abscissæ and the boiler efficiencies as ordinates which express the heat given to the feed water as a percentage of the heating value of the coal used " as fired."

This graph readily pictures the overall performance of these four boilers, from which it will be seen there are some striking differences in the efficiency with which each boiler utilises the heat in the coal " fired " at equal rates of firing. The class " 7 " boiler, though showing generally a rather low thermal efficiency, maintains a relatively high efficiency at maximum rates of working. The class " V2 " boiler, on the other hand, shows a high efficiency, especially through firing rates which are those most common in actual practice. Compared with the class " 7," the efficiency of the " V2 " boiler falls rather more rapidly and is, in consequence, less than that of the class " 7 " at maximum rates of working, which are, however, not normally reached. As a result of this rather lower efficiency, the " V2 " boiler must be fired at a higher rate to reach a maximum evaporation about equal to that attained by the class " 7 " boiler at maximum capacity. The class " 8 " boiler, when fired with Blidworth coal, compares unfavourably with the class " 7 " or the class " V2 " boilers, and of these four boilers it seems reasonable to suggest that the " V2 " boiler is the most economical.

While the graph (Fig. 1) shows the thermal efficiencies of the four boilers when operating under the specific conditions ruling during these tests, in order to appreciate their relative performance, it is necessary to take into consideration the two factors governing boiler efficiency. These are : (1) the efficiency of combustion, this being the heat produced in the firebox as a percentage of the heat in the fuel " fired," and (2) the efficiency of heat absorption, which measures the heat actually taken up by the boiler, expressed as a percentage of the heat produced. The total heat absorbed by the boiler is the total heat transferred across the heating surfaces, and is made up of the heat given to the feed water and appearing as superheated steam, together with that radiated by the boiler to the surrounding atmosphere.

Heat Distribution

For the purpose of making a detailed study of the thermal performance of these boilers, Table II has been prepared, giving particulars concerning the efficiency of the heat distribution. In other words, the information presented shows how each boiler utilises the heat actually produced in the firebox in relation to firing rates (pounds of coal per hour) and for comparative purposes also per square foot of grate area per hour. The table, it will be seen, consists of eleven columns and, for purposes of clarity, each will, when necessary, be considered separately.

TABLE II—*Locomotive Boilers : Heat Distribution*

Blidworth coal

Boiler	Coal fired, lb per hr	Coal fired, lb per sq. ft of grate area, per hr	Excess air, per cent	Boiler efficiency, per cent	Combustion efficiency, per cent	Heat distribution as a percentage of the heat in the coal " as fired "				Efficiency of heat absorption, per cent
						Utilised in evaporation	Heat lost in			
							Outside losses	Unburned coal and imperfect combustion	Smokebox gases	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1 B.R. Class " 8 "	1000	20·6	Not included in test report	82·3	(101·0)	82·3	(2·4)	(−1·0)	(16·3)	(82·0)
	1500	30·7		80·0	98·8	80·0	2·4	1·2	16·4	83·5
	2000	41·2		76·7	95·2	76·7	2·3	4·8	16·2	83·5
	3000	61·8		70·1	87·6	70·1	2·1	12·8	15·4	82·4
	4000	82·4		63·5	80·1	63·5	1·9	19·9	14·7	81·6
	5000	103·0		56·9	72·7	56·9	1·7	23·3	14·1	80·6
	6850	141·0		44·6	58·8	44·6	1·3	40·2	12·9	78·1
2 B.R. Class " 7 "	1000	23·8	64	78·0	96·8	78·0	2·3	3·2	16·5	83·0
	2000	47·6	36	75·1	93·6	75·1	2·2	6·4	16·3	82·6
	3000	71·4	29	72·3	92·5	72·3	2·1	7·5	18·1	80·5
	3500	83·3	28	70·8	90·8	70·8	2·1	9·2	17·9	80·3
	4500	107·1	27·7	67·9	85·8	67·9	2·0	14·2	15·9	81·5
	5066	120·6	28	66·3	82·7	66·3	1·9	17·3	14·4	82·6
3 L.N.E.R. Class " V2 "	1000	24·3	42	84·4	99·3	84·4	2·5	0·7	16·8	87·5
	2000	48·4	32	78·5	96·1	78·5	2·3	3·9	15·3	84·1
	3000	72·7	27	73·4	89·9	73·4	2·2	10·1	14·2	84·2
	4000	102·0	21	67·4	83·1	67·4	2·0	16·9	13·7	83·2
	5000	121·0	16	62·6	78·0	62·6	1·8	22·0	15·6	82·6
	5670	137·5	16	58·5	74·6	58·5	1·7	25·4	14·4	80·7
4 S.R. " Merchant Navy " Class	2000	41·2	47·5	73·23	94·0	73·23	2·1	6·0	18·6	80·2
	3000	61·8	41·0	69·87	91·3	69·87	2·0	8·7	19·3	78·8
	3500	72·2	37·0	68·19	90·2	68·19	2·0	9·8	19·9	77·8
	4000	82·4	33·0	66·51	88·0	66·51	1·9	18·0	19·5	77·8
	5000	103·1	25·0	63·15	84·5	63·15	1·8	15·5	19·5	77·0
	5830	120·3	19·0	60·36	81·9	60·36	1·8	18·1	19·7	75·9

The first four columns consist of what may be termed experimental data, one of which, column 4, gives when available, particulars of the " excess air " supply. This is the percentage of air supplied to the firebox over and above that actually required and utilised in the combustion of the fuel actually " burned."

Boiler Efficiency. (*Column* 5).—The values shown have been computed from the equivalent evaporations in relation to firing rates furnished by the test reports, and have been checked against graphs showing boiler efficiencies plotted against rates of firing. Fig. 1, already referred to, shows the resulting characteristics. As before noted, the boiler efficiencies are based on the " as fired " heating values of the coal used ; further, as the coal used for all the tests had very closely the same calorific value, the graph Fig. 1 not only shows the relative efficiencies in relation to specific hourly firing rates, but also for practically equal rates of heat input on the same basis.

The later test report bulletins issued by British Railways provide graphs giving the relation between the " dry " coal " fully burned " and the coal fired in the " as fired " or " as received " condition. So far as the reports on the class " 7," class " V2 " and S.R. " Merchant Navy " class tests are concerned, the above applies. The heat produced is, therefore, the product of the weight of " dry " coal and the corresponding calorific value and, in like manner, the heat " fired " is represented by the corresponding weight of coal fired and the calorific value " as fired " or " as received." The total heat produced, divided by the total heat " fired " will then give the heat produced in relation to that " fired," which, when expressed as

a percentage of the latter, gives the values in column 6.

The heat actually produced, as represented by a given weight of "dry" coal "fully burned," is determined by a method developed by L. H. Fry, which is delineated in his book, *A Study of the Locomotive Boiler*.[1] This method for computing the efficiency of combustion obviates the necessity for directly measuring the "unburned" coal lost in the smokebox, but does require an analysis of the products of combustion and the combustion gas temperatures also, as will be mentioned later; an estimate of the heat lost by radiation from the boiler to the atmosphere is also necessary. Having determined the weight and temperatures of the combustion gases per pound of coal "burned" this, deducted from the heating value of the coal, gives the total heat taken up by the boiler from each pound of coal "burned." Next, considering the heat absorbed by the boiler per pound of coal "fired," this is represented by the thermal efficiency of the boiler, being the heat utilised in evaporation as a percentage of the heating value of the coal "fired," but is not the total heat transferred across the boiler heating surfaces, part of which is lost by radiation and is not, therefore, available for evaporation. The total heat absorbed by the boiler per pound of coal "fired" is, therefore, that utilised, to which must be added the radiation losses, which will be discussed later.

Assuming the total heat taken up by the boiler per pound of coal "fired" is thus established, this, divided by the heat absorbed per pound of coal "burned," multiplied by 100, will then give the coal "burned" as a percentage of the coal "fired," the remainder being the percentage of the "unburned" coal, the greater part of which is carried out of the firebox in the rapidly moving gas stream.

The heat actually produced in the firebox, expressed as a percentage of the heating value of the coal "fired," is the efficiency of combustion and is equal to the difference between 100 and the sum of the losses due to the coal which escapes "unburned" and to any further heat loss by the formation of CO, both being estimated as a percentage of the heating value of the coal "fired." The combustion efficiency per cent thus found is represented in the test report bulletins by a defined weight of "dry" coal "fully burned" in relation to defined weight of coal "fired," having a heating value in the "as received" or "as fired" condition.

Some remarks on the losses due to heat radiated by the boiler are required, because it is the value given to this particular heat lost which is the key to the Fry method for computing the efficiency of combustion. Originally, Fry assigned a value equal to 5 per cent of the measured boiler efficiency as giving this heat loss, so that the efficiency of the boiler per cent., multiplied by 1·05, would represent the total heat taken up by the boiler per pound of coal "fired." In estimating the heat balances given in his book, Fry used this value, which, in point of fact, appeared rather high in certain cases.

Later, Fry suggested a lower figure of 3 per cent, meaning the boiler efficiency multiplied by 1·03 would give the total heat absorbed by the boiler.[2] This is the value which has been used by the Locomotive Testing Committee, British Railways. Further interesting investigations have more recently been carried out by H. I. Andrews, Ph.D., a member of the Locomotive Testing Joint Sub-Committee, which seem to indicate much lower radiation losses, which are given as being only 0·75 per cent.[3] The heat balances to be referred to later have been computed by using the value of 3 per cent of the boiler efficiency to give the radiation losses. In the case of the class "8" tests made at Swindon, a value of 0·8 of the heat liberated in the firebox was taken as representing radiation losses. The heat balance now given for the class "8" boiler will not, therefore, quite agree with the information given in the bulletin describing these tests, but, apparently, are in accord with previously established practice and, moreover, enable a comparison to be made with the results shown by the other three boilers, which would otherwise not be the case.

Considering now the heat distribution in relation to the coal "fired," the columns 7, 8, 9 and 10 provide all the information that is in practice required. Column 7 is column 5 repeated, being the percentage of the heat "fired"—that is, put to practical use in evaporation. Column 8 gives the outside losses of the heat produced due to radiation and is equal to 3 per cent of the boiler efficiencies, columns 5 and 7. The sum of columns 7 and 8 gives then the heat actually taken up by the boiler heating surfaces per pound of coal "fired." Combustion losses due to "unburned coal" escaping from the firebox and imperfect combustion are given in column 9, these values being the difference between those set out in column 6 and 100. The heat losses in the combustion gases are given in column 10, the difference between the efficiencies of combustion, column 6, and the sum of columns 7 and 8. The final column 11 shows the absorption efficiencies and indicates the heat actually taken up by the boiler heating surfaces as a percentage of the heat liberated in the firebox.

The smokebox gas losses and the efficiencies of absorption are related to each other, together with the value given for the "excess air" supply. At minimum firing rates, when the "excess air" admitted to the firebox is at a maximum amount, the smokebox gases carry a relatively high proportion of heat, though gas temperatures are at a minimum, meaning that the gas produced per pound of coal "burned" is at a maximum. As the firing rates advance, gas production per pound of coal "burned" diminishes and so also does the "excess air" supply. The latter tends to reduce smokebox losses, but also tends to reduce the efficiency of combustion, a fact rather nicely brought out if the performance of the class "7" and class "V2" boilers is compared at high rates of working when the "excess air" percentages are 28 and 16 per cent and the combustion efficiencies, 82·7 and 78·0 per cent respectively at about equal rates of firing, the coal in each case being of the same quality. A note should be made about the results obtained with the class "8" boiler at the minimum firing rate. The heat balance shows in this case a combustion efficiency of over 100 per cent, which is clearly impossible. This discrepancy is due to the value given for the boiler radiation loss being really too high. It is, however, of no particular importance, because this boiler never operates at this low rating, but it does rather indicate that these boiler losses are not, in fact, quite so high as 3 per cent of the thermal efficiency of the boiler.

Perhaps it may be desirable to point out that, in respect to the efficiencies of combustion, these indicate the completeness of the combustion—that is to say, the proportion of the coal "fired" that is actually "fully burned" and that the values given do not indicate to what extent combustion is perfect. Perfect combustion is only measured by the CO_2 content in the products of combustion, and this is governed by the "excess air" supply. The graph (Fig. 2) reproduced by, permission of Babcock and Wilcox, Ltd., indicates in general the relation between

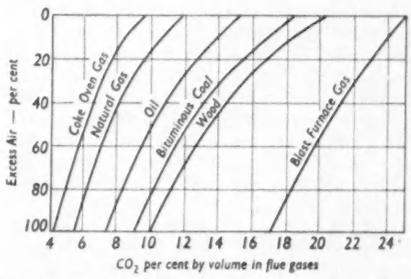


Fig. 2—Planned speed graph for tests and gradient profile

the "excess air" supply and CO_2 for a normal grade of bituminous coal.[4]

Evaporation

The evaporative performance of the four boilers is given in Table III, where firing rates in pounds of coal per hour and also per square foot of grate area per hour are shown and the resulting evaporations per pound of

[1] *A Study of the Locomotive Boiler*, by L. H. Fry, Simmons-Boardman Publishing Corp., New York, N.Y., U.S.A.

[2] "Heat Balances for Locomotive Boilers," L. H. Fry, *Engineering*, April 18, May 2 and 16, 1947.

[3] "Heat Losses of Locomotive Boilers," H. I. Andrews, Ph.D., M.Sc., *Engineering*, August 12, 1955.

[4] *The Principles of Combustion in the Steam Boiler Furnace*, A. D. Pratt. Published by Babcock and Wilcox, Ltd., London.

TABLE III—*Locomotive Boilers: Coal-Fired and Evaporation*

Blidworth coal

Boiler	Combustion			Evaporation			Temperatures, deg. Fah.		Boiler efficiency, per cent
	Coal lb per hr fired	Coal fired, lb per sq. ft of grate area per hr	Excess air per cent	Equivalent water, lb per hr	Equivalent water, lb per lb of coal	Equivalent water, lb per sq. ft combined heating surface per hr	Smoke-box gases	Steam to engines	
1	2,500	50·7	Not included in test report	24,200	9·68	7·55	Not included in test report		73·0
B.R.	3,000	61·8		27,800	9·26	8·74			70·1
Class "8"	3,500	72·0		30,900	8·83	9·72			67·6
	6,850	141·0		40,500	5·91	12·74			44·6
2	2,500	59·5	33	23,900	9·56	7·49	628	675	73·6
B.R.	3,000	71·4	29	28,000	9·33	8·77	655	700	72·3
Class "7"	3,500	80·8	29	32,200	9·20	10·09	676	717	70·8
	5,066	120·6	28	43,500	8·59	13·30	725	730	66·3
3	2,500	60·3	30	24,800	9·94	7·97	625	650	76·1
L.N.E.R.	3 000	72·8	27	28,750	9·50	9·24	660	675	73·4
Class "V2"	3,500	84·8	26	32,000	9·15	10·29	680	700	70·1
	5,670	137·5	16	42,690	7·57	13·70	750	730	58·5
4	2,500	50·6	48	23,900	9·56	7·68	620	575	71·2
S.R.	3,000	61·8	41	27,750	9·26	8·84	650	605	69·8
"Merchant	3,500	82·3	37	31,800	9·12	10·21	675	625	68·1
Navy" Class	5,830	120·3	19	46,600	8·0	14·95	760	675	60·3

coal " as fired " and per square foot of heating surface, which includes the superheaters, because equivalent evaporations are used which are proportional to heat output, which, in turn, is dependent in part on the steam temperatures imparted by the superheater. Smokebox gas and the temperatures of the steam furnished to the engines are also included. The information is based entirely on firing rates showing the heat output (equivalent evaporation) for a given rate of firing coal per hour, the first three of which are those probably prevailing under normal operating conditions. Keeping in mind the remarks already made concerning the operating efficiency of the class " V2 " boiler, it is of interest to note that this boiler develops a higher heat output in proportion to its size than any of the others. Certain information concerning the class " 8 " boiler is, unfortunately, not available, due to the fact that the principal tests were made with " South Kirkby " coal, and detailed particulars are not given in the test report for those tests made with Blidworth coal used, also for the particular tests of the other three boilers.

The Engines

The performance of the class " 8 " locomotive No. 71000 is chiefly of interest so far as the engines are concerned on account of the relatively high powers developed in the cylinders at defined speeds and rates of " cut off " per cent. When compared with other locomotives which have been the subject of tests carried out at Rugby and Swindon, the cylinder powers realised with the class " 8 " engine are outstanding, so much so that on test at Swindon this locomotive developed a maximum of 2640 cylinder horsepower at 90 miles per hour. 408 revolutions per minute, when the rate of " cut off " was only 20 per cent and the steam delivered to the cylinders reached 34,000 lb per hour.

This in itself is a remarkable performance and an outstanding tribute to the locomotive and to the type of valve gear fitted which made it possible to effectively distribute this weight of steam in the cylinders at so short a rate of admission. The performance of the cylinders as above mentioned prompted the present writer to examine more closely the results of the tests under review and as influenced by the type of poppet valve gear used, known now as the British-Caprotti valve gear.

Originally the principles on which this valve gear operates were evolved in 1921 by Ing. A. Caprotti of Milan. The system followed embraced the use of differential cams controlling the two separate " inlet " valves and a single cam operating the two separate " exhaust " valves. The cams rotated at engine speeds, revolutions per minute, and were so designed as to provide large valve openings to " admission " at all rates of " cut off " per cent., so that very considerable port openings were obtained both for " inlet " and " exhaust." It is the very large port opening for " admission " steam, especially at what may be termed " running cut offs " that has revolutionised the efficiency of the valve gear made available with poppet valve gears of this general type. While the tests on the Swindon plant have clearly indicated the advantages offered by this form of valve gear for locomotives, the performance disclosed is not by any means a recent discovery. To appreciate the present position, it is necessary to refer to earlier developments involving the use of this particular poppet valve gear for locomotives on the London, Midland and Scottish Railway.

The Beames Experiments of 1927

The first application of the Caprotti poppet valve gear was made at the Crewe Works of the L.M.S. Railway by H. P. M. Beames, then Mechanical Engineer, Crewe, when one of C. J. Bowen-Cooke's " Claughton " class four-cylinder locomotives, No. 5908, was successfully equipped with this gear in its original form. This initial application was later followed by nine further engines of the same class being fitted with this valve gear and large boilers carrying an increased working steam pressure. As is the case with the B.R. standard class " 8 " locomotives, the cylinder performance of the Beames engines was noteworthy for the high powers developed, thus enabling them to exert a high percentage of their nominal tractive effort at high speeds in association with early rates of " cut off " per cent. Extensive trials were carried out with engine No. 5908 early in 1927, when a number of indicator diagrams were taken at various speeds, miles per hour and " cut offs " per cent. The writer's information is rather limited, but such particulars of the cylinder performance as are available have been examined and the results are set out in Table IV.

The first four lines give information concerning the mean effective pressures shown by some of the indicator diagrams, the boiler steam pressures and the related speeds, miles per hour and also revolutions per minute. The next four lines give the cylinder powers adjusted for the full working pressure of 175 lb per square inch.

Further information given by way of comparison concerns the performance of the G.W.R. " King " class, the L.M.S. " Princess Royal " class four-cylinder locomotives and the B.R. standard class " 7 " locomotives, all having piston valves operated by the Walschaert type of valve gear. It will be noted that these comparisons are made on the basis of speeds in revolutions per minute for the reason that the mean effective pressures are more directly influenced by speeds in revolutions per minute rather than when measured in miles per hour. At " running cut-offs " of 15 and 20 per cent., the Caprotti " Claughton " indicated higher mean pressures in relation to the boiler pressure than any of the other engines so that the cylinders in proportion to their dimensions produced more power or, if preferred, a higher tractive effort.

The last column in the table gives for comparison the actual indicated tractive efforts expressed as a percentage of the rated tractive efforts and again directs attention to the greater efficiency of the valve gear fitted to the " Claughton " class locomotive No. 5908. Following the successful working of the four-cylinder engines, it may be recalled that, in 1931, Beames developed a new design of locomotive intended for mixed traffic working, which was to have been fitted with Caprotti valve gear to give an " efficient distribution " of steam in the cylinders. This design would, it has been stated, have undoubtedly been the standard for this class of traffic on the L.M.S. Railway, had not circumstances arisen which prevented the project from materialising.

Efficiency of Locomotive Valve Gears

Following on the comparative cylinder performance with poppet and piston valves given in Table IV, it may be of interest to consider what is meant by an " efficient " distribution of steam in the cylinders. Presumably, it is the function of any valve gear to produce the highest mean effective pressures possible under any specific running conditions as dictated by the rotational speeds of the driving wheels and prescribed rates of " cut off " per cent. Further, it seems to be generally considered that early rates of " cut off " are desired if the most economical use of high pressure steam is to be realised.[5] In order to form an opinion as to the efficiency of any valve gear, some standard of comparison must be first established. For this purpose, it is proposed that an ideal cycle, suggested by E. L. Diamond, M.Sc., might be adopted.[6] This theoretical indicator diagram assumes that full steam pressure is maintained during the period of " admission," followed by expansion, terminating at " release," when the pressure of the steam would be that corresponding to the number of expansions determined by the rate of " cut off " per cent. and the assumed cylinder clearance volume. Exhaust then took place against a least back pressure taken as being 18 lb per square inch absolute and terminating at a point where compression commenced, which varied in turn with the assumed rate of " cut off," taking place earlier at early rates of " cut off " and later at delayed

Table IV—*Locomotive Cylinder Performance : Piston and Poppet Valve Gears*, 1927–1951

Locomotive	Speeds		Boiler pressure, lb per sq. in	Cut-off per cent	Indicated tractive force, lb	Mean effective pressure, lb per sq. in	Mean effective pressure	Indicated tractive force
	M.p.h.	R.p.m.					Boiler pressure	Rated tractive force
L.M.S. " Claughton " class, 1927 : Cylinders, four, 15½in by 26in Driving wheels, 81in diameter Rated tractive force, 23,600 lb Engine weight, 77·75 tons	35·4	147	170	20	9,840	61·9	36·4	41·5
	45·0	187	170	20	8,550	53·8	31·6	36·2
	64·0	265	165	15	5,600	35·2	21·3	23·6
	37·5	156	175	28	11,280	70·9	40·4	49·9
" Claughton " adjusted for standard boiler pressure, 175 lb per square inch	35·4	147	175	20	10,100	63·5	36·9	42·5
	45·0	187	175	20	8,800	55·4	31·6	37·0
	64·0	265	175	15	5,940	37·3	21·3	25·0
	37·5	156	175	28	11,280	70·9	40·4	49·9
G.W.R. " King " class, 1927 : Cylinders, four, 16½in by 28in Driving wheels, 78in diameter Rated tractive force, 40,300 lb Engine weight, 89 tons	34·0	147	250	20	12,100	64·2	25·6	30·0
	43·5	187	250	20	11,200	59·2	23·7	27·8
	62·0	265	250	15	7,100	37·6	15·1	17·6
	36·0	156	250	30	17,000	90·0	36·0	42·2
L.M.S. " Princess " class, 1933 : Cylinders, four, 16½in by 28in Driving wheels, 78in diameter Rated tractive force, 40,300 lb Engine weight, 104·5 tons	34·0	147	250	20	13,230	70·0	28·0	33·0
	43·5	187	250	20	11,800	62·5	25·0	29·4
	62·0	265	250	15	8,500	44·9	18·0	21·1
	36·0	156	250	30	—	—	—	—
B.R. class " 7 " standard, 1951 : Cylinders, two, 20in by 28in Driving wheels, 74in diameter Rated tractive force, 32,150 lb Engine weight, 94 tons	32·4	147	250	20	10,250	67·9	27·2	31·7
	41·0	187	250	20	9,600	63·6	25·4	29·8
	58·5	265	250	15	6,820	45·2	18·0	21·2
	34·3	156	250	30	14,200	94·0	37·5	44·0

[5] " The Counter Pressure Brake Method of Testing Locomotives," T. Robson, Institution of Locomotive Engineers, 1943 ; " Ten Years' Experience with the L.M.S. 4–6–2 Non-Condensing Turbine Locomotive No. 6202," R. C. Bond, Institution of Locomotive Engineers, 1946.

[6] " The Development of Locomotive Power at Speed," E. L. Diamond, M.Sc., Institution of Mechanical Engineers, 1947, Vol. 156.

rates of " cut off " per cent, thus assimilating in this particular respect the events given by normal forms of valve gear used for locomotives.

With a standard working cycle thus established, a set of graphs was presented, giving, for various boiler working steam pressures, cylinder clearance volumes and rates of " cut off " per cent, the ideal mean effective pressures realised according to the assumed ideal cycle representing the steam action in the cylinders. Referring to Table V, the performance of the Caprotti poppet valve gear, as applied to the " Claughton " class locomotive No. 5908, is compared with the appropriate " Diamond Cycle." The ratio of the actual and ideal mean pressures is then taken as giving the efficiency of the valve gear. Similar comparisons are included for the piston valve gears used for the other locomotives previously referred to in Table IV.

In the case of the Caprotti valve gear, the later " cut off " is not 30 per cent as for the other three engines, but is, as noted, 28 per cent according to the particular indicator diagram. This later " cut off " was deliberately chosen as being favourable to the piston valve gears, which then provide fairly good openings for " admission " steam.

TABLE V—*Locomotive Valve Gears : Comparison of Efficiencies, per cent, Piston and Poppet Valves*

Cut-off, per cent and r.p.m.	Caprotti " Claughton "				Boiler pressure lb per sq. in	Diamond cycle, mean effective pressure, lb per sq. in	G.W.R. " King " class		L.M.S. " Princess " class		B.R. Standard class " 7 "	
	Boiler pressure lb per sq. in	Diamond cycle, mean effective pressure, lb per sq. in	Mean effective pressure lb per sq. in	Valve gear efficiency per cent			Mean effective pressure lb per sq. in	Valve gear efficiency per cent	Mean effective pressure lb per sq. in	Valve gear efficiency per cent	Mean effective pressure lb per sq. in	Valve gear efficiency, per cent
15	—	58	37·3	64·3	—	91·0	37·6	41·3	44·9	49·3	45·2	49·7
265	—	—	—	—	—	—	—	—	—	—	—	—
—	175	—	—	—	250	—	—	—	—	—	—	—
20	—	75	55·4	73·9	—	111·0	59·2	53·3	62·5	56·3	63·6	57·3
187	—	—	—	—	—	—	—	—	—	—	—	—
30*	—	100	70·9	70·9	—	148·0	90·0	60·8	—	—	94·0	63·5
156	—	—	—	—	—	—	—	—	—	—	—	—

Assumed cylinder clearance volumes, 10 per cent.
* 28 per cent C.O. for the Caprotti valve gear.

CLASS " 8 " LOCOMOTIVE CYLINDER PERFORMANCE

The cylinder performance of the B.R. class " 8 " locomotive as shown by the Swindon experiments is given by Table VI. The particulars apply for " cut offs " ranging from 15 to 30 per cent, being those most probably employed ; likewise, running speeds extend from 30 to 70 m.p.h. For the purpose of comparison, the cylinder performance at equal rates of " cut off " and speed is given as developed by the B.R. standard class " 7 " engine No. 70005 on the Rugby testing plant. These two locomotives are in certain respects very similar, notably in the size of the driving wheels and the boiler working steam pressures of 250 lb per square inch.

The relative performance of the cylinders as between poppet valve and piston valve gears is, therefore, of particular interest, more especially because it can be fairly assumed that the piston valve gear may be taken as being designed to provide the optimum distribution, i.e. the most efficient attainable with this type of valve gear. The relative mean effective pressures indicated in the cylinders under the same running conditions are interesting as showing the large increase in the powers available either in the cylinders or at the tender drawbar, made possible by providing considerably improved port openings for " admission " steam. As a case in point, the mean effective pressures are 73·2 and 55·5 lb per square inch at 20 per cent " cut off " and at 60 m.p.h. for the class " 8 " and class " 7 " engines respectively. This means an increase in the cylinder or drawbar horsepowers of 30 per cent if the class " 7 " was equipped with a poppet valve gear, providing similar port openings for " admission " steam. This comparison is favourable to the piston valve gear, as will be realised if the same comparison is made for a " cut off " of 15 per cent when at 60 m.p.h. the mean pressures are 63·8 and 44·3 lb per square inch, a difference of 42 per cent. Keeping in mind the fact that running " cut offs " favoured for normal express passenger trains are about 15 to 20 per cent these actual results might reasonably be expected to be of some interest.

The losses due to throttling at admission with piston valves have frequently been remarked upon, and their extent may be seen if the information given in Table IV is closely examined. An example will make this point clear : Considering, in the first place, the class " 8 " engine at 60 m.p.h. and 15 per cent " cut off," the mean cylinder pressure is 63·8 lb per square inch, and at the same speed and at 25 per cent " cut off " the mean pressure is 81·6 lb per square inch, an increase of 30 per cent. For the same speed and rates of admission, the mean pressures for the class " 7 " engine are 44·3 and 67·0, representing an increase of as much as 52 per cent, almost entirely due to the better port openings at the later " cut off " as is clearly evident when the results with the poppet valve gear are considered and which at all " cut offs " provide more adequate port openings.

The tests on the Swindon plant carried out with the class " 8 " engine bring out the performance of the boiler and the cylinders, to which the present article has been directed. So far as the cylinders are concerned, the results obtained with this class " 8 " engine conform to those obtained with the L.M.S. " Claughton " type engine No. 5908 in 1927 and indicate the scope there still remains for the improvement of steam motive power. The writer hopes the remarks made and the computed data presented concerning the performance of this engine may be interesting and, as such, be a fitting supplement to the articles already published in THE ENGINEER.

Finally, acknowledgment is made of the considerable assistance received from D. R. Carling, M.A., Superintending Engineer, Rugby Testing Station, B.R., especially in setting up the heat balances for the four boilers given in Table II.

TABLE VI—*Locomotive Cylinder Performance : Piston and Poppet Valve Gears.*
Boiler working steam pressure 250 lb per square inch.

Cut-off, per cent	Speed		Engine B.R. class " 8 "			Engine B.R. class " 7 "			Engine data
	M.p.h.	R.p.m.	Indicated tractive force, lb	Mean effective pressure		Indicated tractive force, lb	Mean effective pressure		
				Actual	Per cent of B.P.		Actual	Per cent of B.P.	
15	30	136	13,120	71·3	28·5	8,400	55·7	22·2	B.R. class " 8 " : Cylinders, three, 18in by 28in Driving wheels, diameter, 74in Rated tractive force, 39,080 lb
	40	182	12,515	68·1	27·4	7,700	51·1	20·4	
	50	227	12,000	65·2	26·1	7,150	47·3	18·9	
	60	273	11,750	63·8	25·5	6,700	44·3	17·8	
	70	319	11,340	61·6	24·6	6,250	41·5	16·6	
20	30	136	15,500	84·2	33·7	10,550	70·0	28·0	B.R. class " 7 ": Cylinders, two, 20in by 28in Driving wheels, diameter, 74in Rated tractive force, 32,150 lb
	40	182	14,600	79·4	31·8	9,650	64·0	25·6	
	50	227	14,060	76·4	30·5	9,000	59·5	23·7	
	60	273	13,450	73·2	29·3	8,400	55·5	22·2	
	70	319	12,725	69·2	27·7	7,700	51·0	20·4	
25	30	136	17,610	95·7	38·3	12,600	84·7	33·9	Class " 8 ": Caprotti poppet valve gear
	40	182	16,400	89·2	35·7	11,700	77·1	30·7	
	50	227	15,670	85·2	34·0	10,800	72·0	28·7	
	60	273	15,000	81·6	32·6	10,100	67·0	26·8	
	70	319	*—	*—	*—	9,400	62·2	24·8	
30	30	136	20,050	108·9	43·6	14,750	97·5	39·0	Class " 7 ": Walscheart's gear and 11in piston valves
	40	182	18,800	102·0	40·7	13,600	90·0	36·0	
	50	227	17,750	96·5	38·7	12,500	83·0	33·0	
	60	273	*—	*—	*—	11,650	77·1	30·8	
	70	319	*—	*—	*—	10,850	72·1	28·8	

* B.R. class " 8 " engine. Boiler steaming capacity exceeded at this speed and cut-off per cent.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

DETERMINATION OF THE VISCOSITY OF LIQUIDS IN C.G.S. UNITS

No. 188: 1957. Price 10s. As in the previous editions this revised specification deals with both capillary viscometers and falling-sphere viscometers. The classification " capillary viscometers," however, now includes suspended-level and reverse-flow types as well as the simple U-tube type. For completeness of treatment, a description of the Cannon-Fenske capillary viscometer, used mainly in America, has been included. The reverse-flow U-tube viscometer is now specified for measurement of the viscosity of opaque liquids ; details of the Lee type of viscometer have been omitted.

An important change in the revised publication is that water is now the sole reference liquid, and every capillary viscometer is to be directly or indirectly calibrated against water at 20 deg. Cent. The method of calibration, using master viscometers and a " step-up " procedure, is described.

The appendices to the standard deal with various corrections and ancillary apparatus and with the use of air pressure for extending the application of capillary viscometers to liquids which show non-Newtonian behaviour. The revision has taken account of the methods published by the American Society for Testing Materials and by the Institute of Petroleum ; and for glass capillary viscometers the method now described is technically equivalent to the Institute of Petroleum Method IP/71/57.

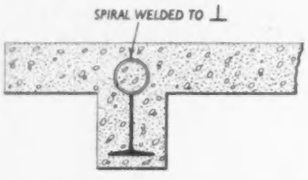
LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

COMPOSITE STEEL AND CONCRETE CONSTRUCTION

SIR.—Herbert Wilson in his letter published in January 31, 1958, issue described a castellated beam, plated on the bottom and acting compositely with a reinforced concrete slab. From this one may assume that he has come to very much the same conclusion that Dr. J. M. Plowman and myself came to some five years ago—that it is necessary to increase the bottom or tension flange above that of the top flange. Since then we have gone one better and, as was described in your issue of November 1, 1957, and is here illustrated, we have done away completely with a steel top flange and replaced it with concrete. Essentially this



is an I beam with a steel Tee acting as the bottom flange and web, and a concrete slab acting as the top flange.

Extensive research has shown that this behaves as a composite beam. As can be imagined the economies obtained by this method are large. When compared with non-composite beams the weight of steel is approximately halved. Whilst the savings using an I section steel beam compositely with a concrete slab are large the savings using a Tee section are even greater. This can be readily understood when it is realised that the neutral axis is approximately at the underside of the slab, so that the steel top flange is practically unstressed. The use of composite Tee sections is shown to its best advantage in multi-storey buildings. Whilst the cost of a traditional steel framed building is something like 25 per cent more than a reinforced concrete framed building (based on the cost of structure including floors) the position can be reversed if composite Tees and columns are used.

R. A. SEFTON JENKINS

Jenkins and Potter,
Victoria Street,
London,
February 4, 1958.

Book Reviews

The Economic and Social Consequences of Automation. By F. POLLOCK. Basil Blackwood, 49, Broad Street, Oxford. Price 25s.

ACCORDING to the introduction to the first German edition, this book is one of a series of inquiries into the changes in the structure of society by the Institut für Sozialforschung at the University of Frankfurt. It will be chiefly of interest to those engineers who are also students of sociology, and they will find the greatest value in the large number of references upon which the book is based—the collection of which must have been a laborious task. It is unfortunate, however, that the author's own views are too often swamped by the mass of quoted matter. He endeavours to maintain a balance between opposing views but virtually the only viewpoint of his own that clearly emerges is that planning on a grand scale, involving the Government, the employers and the trades unions, is the only way to offset the disasters that automation could, according to his concept, bring to the working population. It is obvious that the author accepts the idea that automation is really a second industrial revolution and that it will be as inimical to workers as was the first industrial revolution (but are we so sure that this was as black as it is now painted *vis-à-vis* the preceding periods?).

The author opens with a long dissertation on "What is Automation?" He gives no definition until he reaches the third chapter: but says that "the similarity between the first and second industrial revolutions lies in the fact that in both cases a large number of scientific discoveries and technical inventions culminated in the development of a new type of industrial production and also led to fundamental changes in the social structure. These technical and social changes represent something more than a step by step development from the old to the new. They have produced something 'new' in a qualitative as well as in a quantitative sense. It is this aspect of modern change in industry and society which justifies the use of the term 'second industrial revolution.'"

In the second chapter the author takes to task those who think that any disturbance caused by automation will be of a short term nature and that workers rendered redundant will quickly find new employment since the reduction in costs will quickly stimulate an increased demand leading to an expansion in output. This "compensation theory"—this self regulating mechanism of the free market is rejected in these terms: "In the long run it is possible that the holders of the compensation theory may be right but we have to consider the short term, as well as the more remote, effects of automation."

Nearly all the evidence that appears in this book is drawn from the United States and several pages are devoted to show that the full employment that the Americans believe they have enjoyed, since the end of the second world war, is largely a myth and that with a return to a veritable peace time economy there could be as many as 10,000,000 out of work. This estimate was made to draw attention to the magnitude of the problem that could arise with a reduced army and no re-armament, but the inference is that, if those displaced by automation redundancy were added, the results would be catastrophic.

After some generalisation in the third chapter the author gives a number of definitions of automation including his own: "Automation is a technique of industrial production combined with a method of processing data, introduced since the second world war. With the aid of the most advanced techniques and devices—but with certain economic limitations—this method of production attempts to perform by machinery all the functions hitherto performed by human beings. The machines are 'controlled' by machines."

The progress of automation in 1955 is the subject of Chapter V. Operations research and computer methods are discussed together with automatic programming; automatic filing, automatic assembly, transfer machines and machines operated by numerical control are considered.

The economic consequence of automation is the text of the following chapter. The author confesses, in almost as many words, to being baffled by the absence of any systematic survey of the amount of automation installed or of its effects. In endeavouring to assess the situation he again quotes instances of automation in different fields and attempts to draw evidence from individual cases. Peter Drucker receives some rough handling here and later. The following remarks are of special interest: "Our examination of reports available concerning the effect of automation in the U.S. in 1955 leads to a negative conclusion. We have found no evidence in these reports which could lead us to alter the views that we have expressed concerning the danger of mass unemployment owing to automation. In 1955 the redundant workers did find new jobs but that does not mean that their successors in later years will be equally fortunate." This is surely the bolstering up of a preconception.

The penultimate chapter bears the title "New light on the social consequencies of automation." In it the author says that "the educational system as a whole will have to be radically changed in order to give training suited to an automatic age . . . It is possible that the technical colleges are training their students in skills that may already be out of date when they enter industry." The question of the proper use of increased leisure is raised—"the change from a leisured class to leisured masses." Up-grading or down-grading of workers is considered pro and con. It is admitted that work will be much lighter but feared that mental strain may take the place of physical effort. The difficulty of long-term planning that is involved in automation is stressed as is the further difficulty of adapting an automated plant to armaments should war come. The broad effect of management decision on many lives is discussed and the heavy burden placed on managers in making these decisions is sympathetically considered. The tendency toward overgrown businesses, to which automation may contribute, is discussed. Also the effects of automation on the smaller firms is reviewed. The attitude of the American trades unions to automation occupies a place in this long chapter.

There is a brief but, on the whole, a hopeful final chapter entitled "Automation—Blessing or Curse?" Government planning emerges as the specific for all the imagined ills that automation may bring. In the final paragraph we find "... the object of economic planning must be to integrate automation with a free and democratic society. Success in such planning would mean that the second industrial revolution

could help to establish a social system based upon reason."

The work has suffered in translation or in proof reading : for example the name of the vice-president of manufacturing of the Ford Motor Company who gave birth to the term "automation" is rendered as Darder instead of Harder. We also read that twenty-six machines turn a six-cylinder steel block into an engine block. There are so many mistakes of this kind that the reader might be excused if he should wonder if there are any that he has not discovered. Moreover, the pages are spoiled by far too many footnotes which badly break the reading sequence. In other respects the book is well produced, has an excellent bibliography and a really adequate index.

Conference on the Utilisation of Heat From Nuclear Reactors, Harwell, January 18, 1957. A.E.R.E. CE/R 2257. H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 10s.

BECAUSE of the interest that had been shown in the possibilities of nuclear *heating*, as distinct from steam raising for power, a conference was held at Harwell on January 18, 1957. There were seven papers, after an introduction by Sir John Cockcroft, and the proceedings are now published in the form of an "unclassified" report of the U.K.A.E.A. Research Group. As Sir John explained at the beginning of the conference, nuclear heat is in principle cheap, and at the time he spoke it was already being investigated by the Swedes for district heating and by the Norwegians for pulp and paper production. The cost of fuel for large-scale users of heat was about 36d. per 1,000,000 B.Th.U. While he refrained from discussion of the reactors that might eventually prove suitable for heating, Sir John pointed out that the important question for members of the conference was how far the capital cost would fall by 1965, when he expected that the fuel cost for reactors using natural uranium would have declined to 6d. per 1,000,000 B.Th.U.

The first paper delivered to the conference indicated the different kinds of reactor available. Dr. J. V. Dunworth (A.E.R.E., Harwell) selected for his audience the key points from his address to the fifth World Power Conference (the original paper, slightly modified, is reproduced in an appendix). Sir Sydney Frew (Ministry of Power) then enumerated the greater national users of heat, and showed from what sources they presently drew their energy. He concluded that it was vital to save our dwindling reserves of conventional fuels, and that it was therefore important to develop ways of using nuclear heat along all possible lines. The high-temperature reactor might provide the key to the production of liquid fuels and petroleum products from coal. In the next paper, Mr. G. Nonhebel (I.C.I.) went further into the steam requirements of large-scale chemical plant, and emphasised that the need for reliability in large factories carrying out complicated processes was absolutely essential. Crash shut-downs could have disastrous effects. Heat from smaller nuclear furnaces would be exorbitantly expensive in capital cost. Even in industrial power stations, competition with coal-fired furnaces would be difficult in those cases where most of the power was generated by back-pressure and pass-out turbo-alternators : large industrial power stations produced power appreciably more cheaply than it could be bought from the grid.

The heat requirements of another great user of heat, the iron and steel industry, were outlined by Mr. L. H. W. Savage (British Iron and Steel Research Association) in the third paper of the conference. He pointed out that a total of about 1550MW of heat was needed in an integrated iron and steel works, this at temperatures of about 1200 deg. to 1600 deg. Cent. After this the ball was thrown back to the A.E.R.E., Mr. C. M. Nicholls of Harwell offering some thoughts on the industrial use of heat from nuclear reactors. He considered that the scale of application would have a pronounced effect on the economics, and that safety would have to be assured to a standard to make reactors acceptable in industrial environments. If, in applications to processes, the same reactors could be used as were now being developed to supply steam to turbo-alternators, this would be desirable, but such desirability should not be taken as an overriding limitation at the present stage. Dr. Idris Jones (National Coal Board) followed with a paper on nuclear heat and the coal industry. In his view both nuclear and coal-fired heating had their places, the former for low temperatures and the latter for high. He reviewed the possible uses of nuclear heat in coal processing and the production of gas. Sir Charles Ellis (Gas Council) read a paper in which he suggested that nuclear heating might be applied in the hydrogenation of oil or coal. The hydrogen required could be produced by methods using temperatures below 800 deg. Cent. A further possibility which he thought could at least be considered, was to gasify with oxygen and steam the solid residue left by the first rapid reaction in hydrogenation, producing carbon dioxide, and then to use hydrogen and heat with this to evolve methane ; the hydrogen, oxygen, steam and power could all be derived from water, using the energy of uranium fission, so making every atom of our indigenous carbon available as a carrier of high-grade chemical potential energy.

Mr. J. Leicester began the last paper by explaining that he did not wish to raise false hopes for the application of atomic energy to the laundry industry, and the solution of his hearers' domestic problems as a result ! He spoke more in connection with his past work in the Admiralty than in his present capacity as director of research at the British Launderers' Research Association. He felt that nuclear power could play a very large part in future in the purification of water. The heat levels required were those available from nuclear sources. He thought that it was perhaps not fully realised how great a problem the provision of fresh water was in various parts of the world. There was definitely a world shortage of *fresh* water, and this commodity was needed if industry was to develop in certain territories. Mr. Leicester then discussed evaporative and solvent extraction techniques for the purification of brackish water, comparing the economics of different methods of heat raising in each case. The conference was summed up briefly by the chairman, Mr. A. S. White.

The proceedings are mimeographed, and stapled together in stiff paper covers. There are 88 pages.

Books Received

Rockets, Missiles, and Space Travel. Revised edition. By Willy Ley. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 50s.

British Chemical Plant, 1957 Edition. British Chemical Plant Manufacturers' Association, 14, Suffolk Street, London, S.W.1. Issued free of charge.

The Modern Port. By H. Fugl-Meyer. Danihs Technical Press (Teknisk Forlag), Vester Farinragsgade, 31, Kebenhavn V, Denmark. Price D.Kr.22.50.

Technical Reports

Scale Effects at High Subsonic and Transonic Speeds, and Methods for Fixing Boundary-Layer Transition in Model Experiments. By A. B. Haines, B.Sc., D. W. Holder, Ph.D., and H. H. Pearcey, B.Sc. Reports and Memoranda No. 3012. H.M. Stationery Office. Price 11s.—The major scale effects at high subsonic and transonic speeds arise from differences between the conditions under which laminar and turbulent boundary layers separate, and in how they behave after separation. For turbulent boundary layers, these conditions and behaviour do not vary greatly as the Reynolds number is changed, and in many examples it has been shown that they are similar for the turbulent layers that occur naturally at high Reynolds number and for boundary layers in which transition to turbulent flow is fixed artificially. The scale effects arising in wind tunnel tests made at low Reynolds number may, therefore, often be minimised by fixing transition to turbulent flow by introducing an artificial disturbance such as that produced by excrescences attached to the surface. The fact that the effects of separation are often less severe for laminar layers than for the turbulent layers that are likely to be encountered at full scale, makes it all the more important to do this whenever possible.

Several methods which can be used to fix transition are described, and the results obtained by using them are compared. In general, in experiments in two-dimensional flow, good agreement is found, and explanations can be advanced for cases in which discrepancies occur. Several uncertainties and difficulties that arise in fixing transition are discussed and illustrated by examples. In particular, special care is needed in interpreting the results obtained with transition fixed at very low Reynolds numbers (say, less than about $R = 1 \times 10^6$ based on local chord for wings of about 0·1 thickness/chord ratio and possibly higher Reynolds numbers for thinner wings).

The difficulties of fixing transition satisfactorily are increased for three-dimensional wings, particularly if they are swept back or highly tapered (i.e. small chord and Reynolds number near the tip) and if the tests cover a large range of incidence, including high incidences for which the flow may separate from very close to the leading edge. Under these circumstances, it is frequently necessary to place the excrescences at different chordwise positions for low and high angles of incidence, and this is inconvenient in practice. More research is needed before sound recommendations can be made as to how and where transition should be fixed on such models, particularly since in routine testing it is often not possible to check the effects of transition fixing fully.

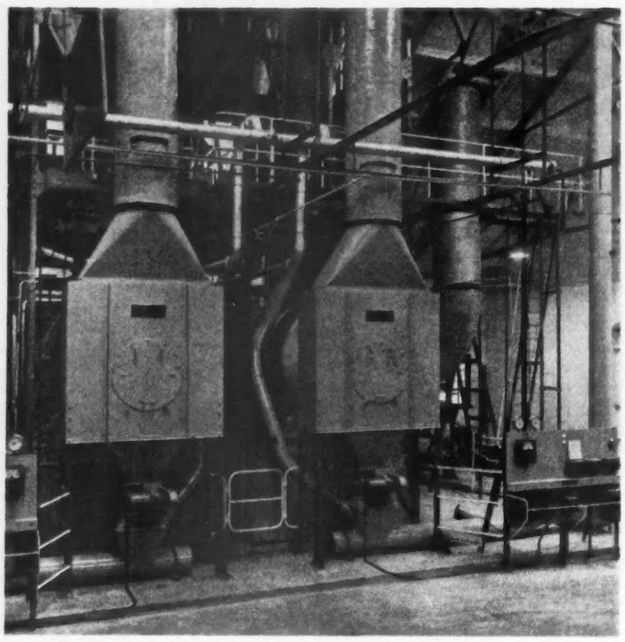
In the sections dealing with three-dimensional tests, examples are given of the spurious results that have been avoided successfully by fixing transition, of the conditions where even at low Reynolds numbers artificial fixing of transition may not be necessary to give a turbulent boundary layer ahead of the shock, and of the conditions under which there are some doubts whether the methods used for fixing transition have been satisfactory.

Wärmediagramme fuer Vergasung, Verbrennung und Russbildung. By F. Bosnjakovic. Berlin-Göttingen-Heidelberg : Springer-Verlag, Reichpietschufer 20, Berlin, W.35, German Federal Republic. Price DM.43.50.—This collection of nearly eighty thermodynamic equilibrium diagrams will be found useful by those who wish to understand the mechanism of the gasification and combustion of fuels. The many scale diagrams permit the finding, without calculations, of the properties of the resulting equilibrium gas, at pressures of 1, 10 and 25 atmospheres, for gasification with air and oxygen, of coke and other fuels. In addition, the author seeks to describe clearly the complex interaction of chemical reactions, and the resulting material and heat exchanges which occur during gasification. The resulting $i\zeta$-diagram is stated to be very similar to the ix-diagram for moist air. In the last section a thermodynamic treatment is given of the formation of soot, whether occurring unintentionally or for the purpose of soot manufacture.

An Experimental Verification of the Theoretical Conclusions of R.A.E. Technical Note Structures 156 *(A.R.C., C.P. No.* 286), *A Constructional Method for Minimising the Hazard of Catastrophic Failure in a Pressure Cabin, with Further Comments on its Implications.* By D. Williams, D.Sc., M.I.Mech.E., F.R.Ae.S. Current Paper No. 357. H.M. Stationery Office. Price 2s. 6d.—In a recent paper, the author described a method of construction intended to make the shell of a pressure cabin immune from catastrophic failure at little or no cost in extra weight. The present note records the results of experiments carried out on a "Comet I" cabin that was modified to incorporate the new constructional method. These experiments, which include some very searching tests, amply confirm the benefits indicated by theory, and appear fully to vindicate the new method of construction.

The note also touches on the momentous implications that arise once this type of construction is accepted as meeting the claims made for it.

Wood Chip Drying Plant



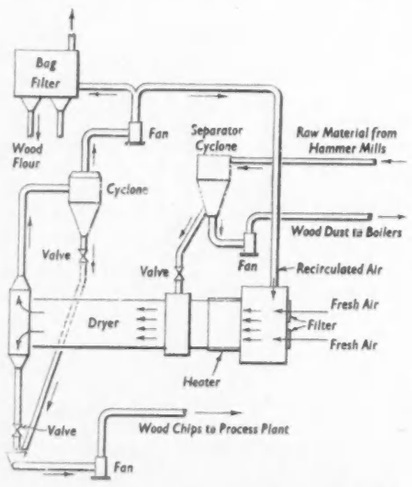
The increased supply of wood chips required to meet the expanding demands for Man Made Timber exceeded the capacity of the existing drying plant so that the Airscrew Company and Jicwood, Ltd., took the opportunity to replace the old with more modern and efficient equipment. This has a capacity sufficient to satisfy present demands and those of the new wood chip board plant. The wood chip drier can be seen in the illustration to the right, which is a view looking at the delivery end of the rotary driers.

TIMBER shortage after the war sponsored the development of Man Made Timber in which industrial wood waste was utilised to produce wood chip board. The new industry expanded since it was of economic advantage to the country in converting, in addition to industrial wood waste, forest thinnings and under-developed timber into a useful product while at the same time effecting a saving in costs by rendering disposal unnecessary. The Airscrew Company and Jicwood, Ltd., Weybridge, Surrey, has been associated with these developments and produce "Weyroc" Man Made Timber in a variety of forms. Expanding demand and the need to meet it with increased production has called for increased drying capacity. This was not possible with the existing driers, since they were already operating at a maximum, so that it was necessary to install new equipment. Apart from the question of capacity, the driers in question had been converted from grain driers which, although still serviceable, were not very efficient by modern standards, so that both running and maintenance expenses pointed to the need for the renewal of the plant. It is of interest to note that the capacity of the new drying equipment is such that it will be able to serve the additional the plant which is to be installed at Weybridge for the purpose of producing annually 20,000,000 square feet of a new grade of "Weyroc" Man Made Timber.

The overall design of the drying plant, which consists of two units, has been largely the responsibility of the company and it has manufactured all the fans, associated ducting and ancillary equipment, while the installation of the equipment and the necessary supporting structure has been the responsibility of the maintenance department. In this section of the plant all the fans are used for conveying the wood chips and are of the Airscrew standard paddle blade centrifugal pattern commonly used for material handling. The heaters and drying drums have been designed and manufactured by the Sturtevant Engineering Company, Ltd.

Raw material, mainly soft wood industrial waste, is collected from joinery factories and delivered to the factory, either in box vehicles specially designed to suit factory exhaust systems or in bags, and discharged into a chip storage bay. From storage the raw material is hand fed on to a belt conveyor, at floor level, which is rated to handle about 3 tons per hour of dry material and between 4 to 5 tons of wet material. The operator, in loading the conveyor, roughly grades the chips according to colour and, to some extent, the moisture content. At the delivery end of the conveyor there is a magnetic metal detection unit and the chips are fed into a pneumatic system, the entry into which is so designed that any large pieces of wood or other foreign bodies are separated out under gravity. Overhead ducting conveys the chips to a hopper which feeds four swing hammer mills, provided by Miracle Mills, Ltd., in which the raw material is reduced to chips of a uniform size measuring approximately $\frac{1}{4}$in by $\frac{3}{32}$in. Each mill is cleared by its own fan, of centrifugal paddle blade pattern from the Airscrew standard range, which passes the chips to two booster fans, each of which supplies a drying unit.

Our line drawing gives a diagrammatic layout of the installation, to which the feed from the grinding mills is delivered at a speed of about 3500ft per minute to a separator cyclone. This is a standard unit, having an internal perforated cone in which centrifugal action causes the chips to be thrown to the outside and the dust to pass through the perforated cone and be drawn downwards through a central orifice at the base by a 10in diameter paddle blade fan; this is rated at 2500 cubic feet per minute at 5in w.g., and delivers the dust through ducting at a speed of 3500ft per minute to a booster fan. This forwards the waste to be burnt in two W.I.F. Babcock and Wilcox boilers each having an evaporation rate of 11,000 lb per hour and generating steam at 165 lb per square inch gauge and 550 deg. Fah. There are also two Sterling watertube boilers rated at 13,000 lb per hour at the same pressure and temperature. The steam so raised is supplied to a Metropolitan-Vickers pass-out turbine driving an alternator which provides about 80 per cent of the electrical power required by the works.



Diagrammatic arrangement of drying plant

From the separator cyclone the chips are ducted to and fed by an electrically driven rotary valve to the entry box of the drier, where a chute distributes the material into the lower half of the shell of the rotary section of the drier. This consists of a horizontal cylinder, measuring about 5ft in diameter by 21ft in length, fitted internally with a series of lifting and directional flights which cause the chips to cascade through a stream of hot air, at the same time moving the chips towards the discharge end. The drum, the axis of which is inclined slightly, is rotated at a speed of 3 r.p.m. and the average time for the material to pass through is approximately $3\frac{1}{2}$ minutes. The dry chips fall into the discharge box and are gravity fed to an electrically driven rotary valve from which they pass into a hopper feeding into a pneumatic system. This is powered by a $12\frac{1}{2}$in diameter paddle blade fan, rated at 3200 cubic feet per minute at 6in w.g., which delivers the material at a speed of 3500ft per minute to a storage bunker in the process plant. From here it is fed to the mixing sections where binding material is added to form a final mixture ready for the manufacturing into boards.

As already mentioned, the chips are air dried, and the air is drawn into and circulated within the system by a 25in paddle blade fan having a rating of 6700 cubic feet per minute at 4in w.g. The air consists of recirculated air and fresh air, the fresh air being drawn into the mixing chamber through filters fitted with manually adjustable louvres, while the amount of recirculated air used is governed by the moisture content and the ambient temperature. The mixture of fresh and recirculated air is drawn through a heater consisting of a battery of closely spaced gilled tubes. Steam at 40 lb per

square inch gauge from the pass out turbine is supplied to the first two banks of heater tubes, the remaining sections being supplied with steam at 135 lb per square inch gauge, as required, and controlled by an automatic regulator. The regulator setting is governed by rate of flow of the raw material, the atmospheric conditions and the moisture content of the raw material. The latter is checked at intervals on samples taken from the conveyor in the storage bay by assessing the moisture content by infra red drying and weighing. The temperature of the heater is based on the foregoing data and this setting controls the steam valve and hence the amount of steam admitted.

Air moving at a speed of about 340ft per minute enters the drier at approximately 320 deg. to 330 deg. Fah., and leaves, after passing through the cascading wood chips, at about 180 deg. to 200 deg. Fah., at the discharge box where its velocity is reduced. From this point the air, which has picked up a certain amount of fines and fine dust in the drier, is ducted to a cyclone at a speed of 1800ft per minute, where the fines are separated out and returned to the flow of process material through a rotary valve. From the cyclone the air is drawn to the main circulating fan, the particulars of which have already been noted, which forwards the air in part to the mixing chamber for re-circulation, the proportion being dictated by the plant requirements, and the remainder via ducting to a filter unit. This contains 144 calico bags, of about 11in diameter by 7ft long, which are suspended and through which the air passes and which collect the fine dust or wood flour. The clean air is discharged to atmosphere and the wood flour drops from the bags into hoppers and is bagged ready for disposal.

Air Suspension for Road Vehicles

By J. H. SAINSBURY*

No. I

On Tuesday last a brief account of the past applications of air springs, principally in the United States, was given to the Automobile Division of the Institution of Mechanical Engineers. We record below the account of one of the less familiar forms of spring.

EACH year the spring frequency considered most suitable for all-round comfort appears to be lowered. In the early 1930s a frequency of 125–135 c/min was thought to be ideal, while in the late 1930s, this was reduced to 90–110 c/min. With the innovation of air suspension this figure was reduced to 80–85 c/min. However, recent developments in the United States are being centred around frequencies of 40 c/min. This, together with the fact that 80 c/min attainable with a two-convolution bellows is not suitable for passenger car suspension, has led to the development of a single convolution spring for applications where frequencies below 80 c/min are required.

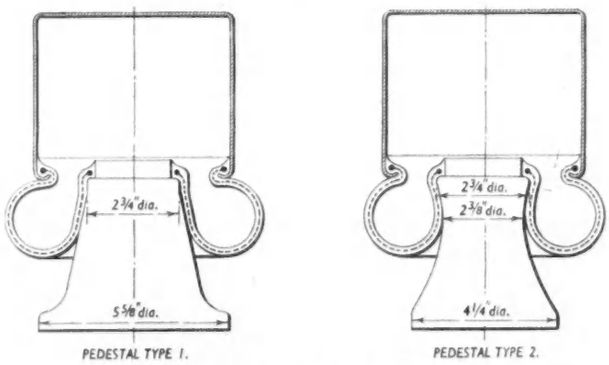


Fig. 1—Comparison of pedestal shapes

Another feature which led to development of the single-convolution type was the shape of dynamic load-deflection curve considered desirable for passenger car suspension. Such springs can be divided into two types :

(1) Those with a centrally located shock absorber and

(2) Those where the shock absorber is located outside the spring.

Type 1.—This form of installation has its complications in that the oil seal between the strut and tube must be airtight up to pressures of 200 lb per square inch as this pressure is often encountered in the full-bump position. Also a section of the shock absorber is enclosed in the bellows and the problem of adequate cooling has to be overcome.

Type 2.—A single-convolution bellows appears in Fig. 2. A steel pressing is moulded into the inner bead to provide an airtight seal. The outer bead is a self-sealing fit into the reservoir, in the same manner that a tubeless tyre bead is self-sealing. The inner bead is a push fit on to the pedestal, which is mounted on either the axle or a radius arm.

The shape of the lower pedestal over which the spring rolls and the volume of the reservoir can be varied to give different characteristics using the same spring. As an example Fig. 3 illustrates a single-convolution spring mounted on two different pedestals. Fig. 3 shows the resulting dynamic load curves calculated with the same reservoir capacity. It will be seen that there is little change in the rebound section but that considerable differences are attainable in the bump stroke.

Fig. 2—Single-convolution bellows with sealed inner bead

It has been found desirable to operate this type of spring at as near 100 lb per square inch as possible for maximum load since the higher the air pressure the lower will be the reservoir capacity required to achieve a given frequency. It is possible to design this type of installation to give a frequency as low as 40 c/min with relatively small reservoir capacity which is admirably suited to passenger car installations.

The two limitations to this type of spring are : (*a*) the operation pressure for minimum load should not be below 40 lb per square inch since at lower pressures the bellows will not form itself around the pedestal as designed and (*b*) owing to production limitations it is not possible to design the effective area below 11 square inches. Thus, the minimum load that can be catered for is in the region of 400 lb. For a light vehicle with, say, a kerb weight of 1400 lb at present employing direct-acting springs, it would be advisable to install independent suspension at the front so as to increase the load on the spring. The rear axle could possibly be mounted on radius rods with the spring located between the fulcrum point and the axle. However, there are many ways of installing air suspension and it is obvious that vehicle designers will have their own ideas. It is thought that the whole subject is one which can best be developed by co-operation between the supplier of the bellows, makers of the control valves and the vehicle manufacturer.

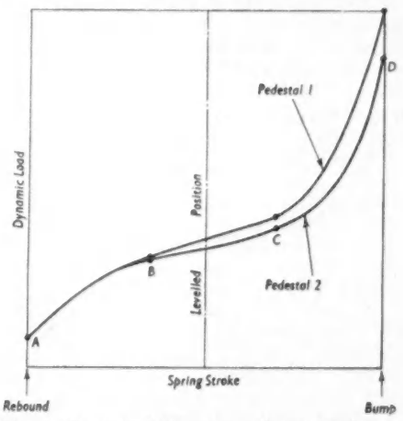


Fig. 3—Dynamic load curves using pedestals of different profiles

The Future

It is considered that the advantages of air suspension will lead to its general adoption in due course. With its introduction into passenger car suspension it is possible that tyres will be put to their correct use, that is, to provide traction. It is well known that pneumatic tyres, an existing type of air suspension, provide an important part of a vehicle's suspension. This is the main reason for operating pressures of 24 lb per square inch. With the introduction of air springs it is possible that higher tyre pressures may come about.

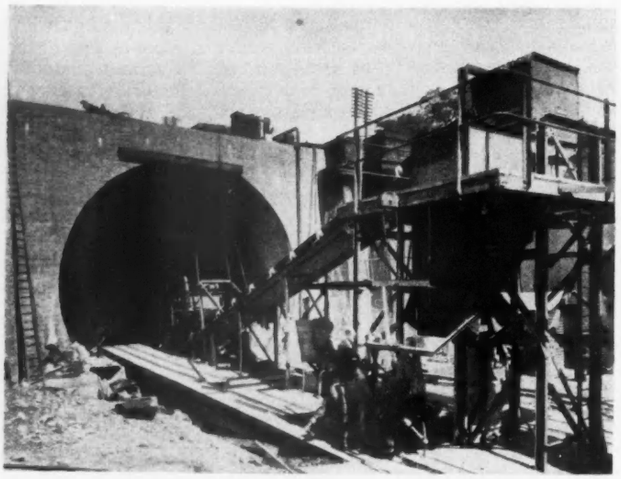
The addition of a compressor to passenger cars will possibly lend itself for use as a power drive for existing auxiliaries, for example windscreen wipers. It is thought that a compressor with a capacity of about ½ cubic foot per minute at a pressure of 120 lb per square inch will be suitable for the suspension system.

(To be continued)

* Development Engineer, Firestone Tyre and Rubber Company, Ltd., Brentford.

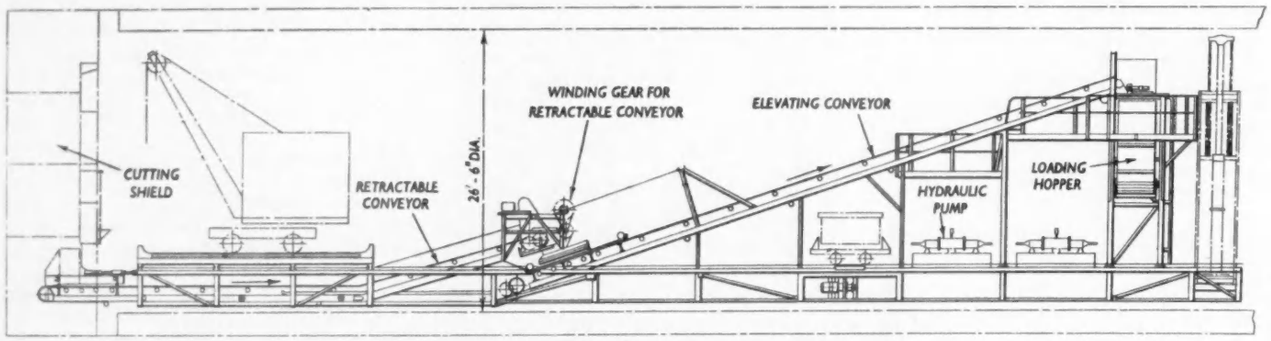
New Tunnels at Hadley Wood and Potters Bar

Three double-line tunnels are being constructed in connection with the doubling of the East Coast main line between New Barnet and Potters Bar stations. These tunnels are being driven in hard clay using shields and a specially designed loading installation at the face. They are being lined with concrete segments and have lengths of 384, 232 *and* 1214 *yards respectively.*

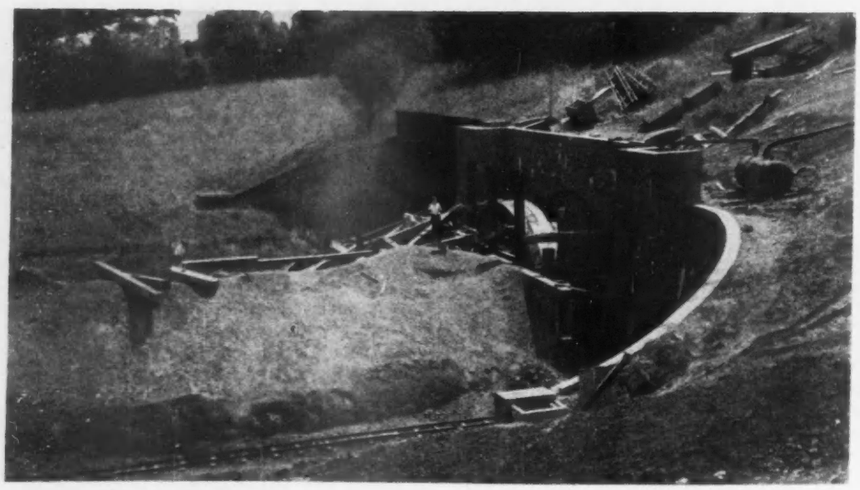


AN important part of the work involved in the widening of the East Coast main line south of Potters Bar station in the Eastern Region of British Railways, to provide four tracks towards London, is the driving of three new tunnels. It will be recalled that in the reconstruction of Potters Bar station, which was completed in 1955 and described in our issue of December 2, 1955, the four tracks were extended southwards to within some 365 yards of the Potters Bar tunnel. Under a stage of the widening scheme now in hand the three double-line tunnels, which are 384 yards, 232 yards and 1214 yards long respectively, are being duplicated.

When this tunnelling work was being planned problems arose owing to the fact that no similar double-track railway tunnels in clay had been constructed in this country for about forty years. The last work of this kind was the Ponsbourne tunnel, which was excavated in the traditional way by miners and lined with seven rings of brickwork. At the time the new tunnels were planned the use of the very large number of miners which would have been required for the work was out of the question, suitable bricks were in short supply, bricklayers used to tunnel work were scarce and there were not many engineers familiar with large, soft new tunnelling work. The Eastern Region of British Railways approached Sir William Halcrow and Partners, who put forward a design for the tunnels. Apart from this consultation and the detailed design of the tunnels as well as the appropriate parts of the contract document, all the drawings and the design of the scheme as a whole was undertaken at King's Cross in the Chief Civil Engineer's office.



General arrangement of spoil loading installation behind travelling shield



Portal at start of tunnelling operation, with buttressed pile structure to form an anchor to take the shield reaction thrust

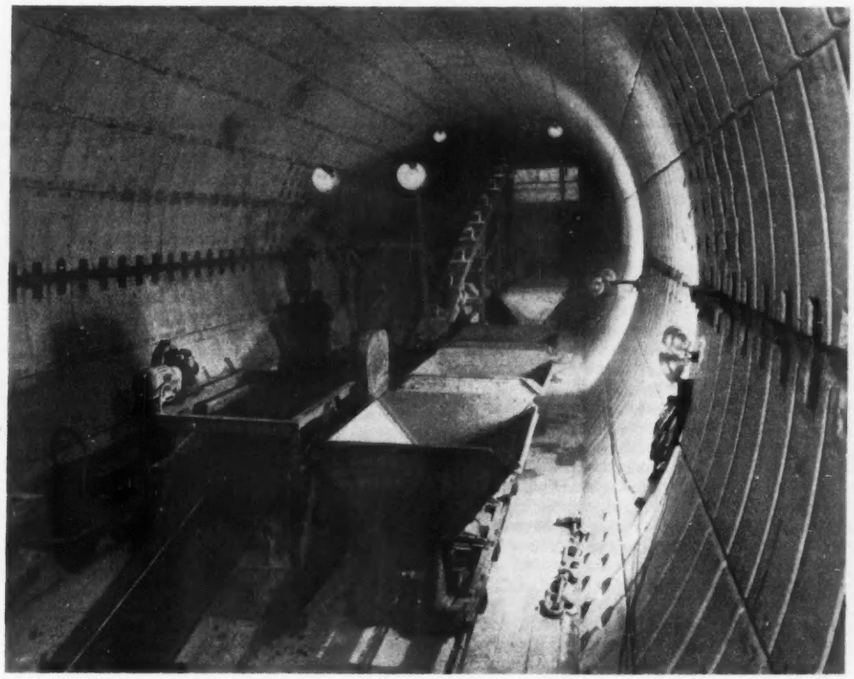
The actual contract for the work was placed with Charles Brand and Son, Ltd., and in the course of a recent visit to Potters Bar we were able to see the progress made to date and the methods and equipment being used. For the new tunnels there is being used a lining built up with precast concrete units and a special works has been laid down in the area by the contractors for the construction of these units. As steam locomotives will use the tunnels for some years to come "Sealithor" metallurgical supersulphated cement has been used in the making of the units with the exception of a large invert segment which is situated below the ballast level. Each ring of lining comprises a reinforced concrete invert unit at the base with nineteen plain voussoirs or segments completing the ring above. The rings are 18in wide, 27in deep and are built to an internal diameter of 26ft 6in.

The tunnels are driven in 31ft diameter cutting shields designed by the contractors and built to their requirements by Joseph Westwood and Co., Ltd., of Millwall, London, E.14. A shield is of fabricated steel construction and is driven forwards into the clay by twenty-five hydraulic rams spaced round the rear of the rim and bearing against the last ring of lining segments. These rams are designed to exert a total thrust of

1000 tons. At the face side the shield chamber has three transverse platforms subdivided to form compartments. Miners in these compartments dig the clay out with pneumatic spades and the spoil is shovelled into two vertical chutes leading down to a conveyor. Each time the shield is pushed forwards its rams are retracted for the next lining ring to be inserted whilst excavation proceeds. Face support hydraulic rams at the front of the shield retract as the rear rams are extended in the driving operation.

In the lining segment placing operation the large bottom invert segment, weighing some $4\frac{1}{4}$ tons, is first placed in position by a crane. The segments to be placed above this invert are then assembled on curved erection arms on each side of the rear of the shield assembly, as shown in one of our illustrations. These arms are pivoted at the base and are raised by means of hydraulic rams to set the lining segments in position round the tunnel. The crown segment is raised by a small lift hoist and placed in position before the arms are retracted. At waist level on each side of the ring of segments a pair of the voussoirs have vertical slots inset and when small jacks placed in the slots are extended the complete ring of units is forced tightly round its periphery into contact with the ground all round the tunnel. The crown unit hoist is then retracted and the elevating arms are free from their loads. The slots with the jack connections protruding can be seen in the illustration. Whilst the jacks are extended a dry concrete mix is inserted in the slot between the spaced segments. This concrete sets in about twenty-four hours, after which the jacks can be removed and their slots filled with concrete. Where openings occur in the tunnels for refuges and the throats of air shafts, special methods are adopted, including the use of concrete shear keys between adjacent rings, to support the loads on an incomplete ring. High strength steel tension rods are also incorporated, to impart the required degree of strength to the lining.

For the removal of spoil during excavation the belt conveyor equipment shown in the accompanying drawing was built by the Fraser and Chalmers Engineering Works of The General Electric Company, Ltd. This equipment is carried on a steel framework 116ft long, 17ft wide and 23ft 6in high. Mounted on it are two 36in conveyor belts, the first of which is retractable in order to allow the invert block to be inserted. A platform and track for a 3-ton travelling crane are situated over the retractable conveyor. Rail tracks of 24in gauge are laid down the whole length of both sides of the framework, and an electrically operated traverser is provided under the second (elevating) conveyor for moving the wagons from one side to the other. The spoil-loading hopper is at the rear discharge end of the elevating conveyor.



Conveyor installation as seen from the working face with line of trucks in position under loading hopper. The recesses at tunnel waist level for the segment extending jacks can be seen on the right

An hydraulic accumulator and compressed-air-driven pumps for operating the rams are mounted at the rear of the framework, which also carries all the necessary electric motors and switchgear. Skids underneath the framework rest on greased concrete ledges, which are integral with the invert blocks. The whole of this assembly is linked to the cutting shield by two screw couplings and advances with it. A single-line rail track of 2ft gauge runs into the tunnel and from a turn out near the cutting face the lines run down both sides of the tunnel and are connected to the tracks on the conveyor assembly.

Diesel locomotives run empty skip trains on to the track on the right-hand side of the conveyors. From this track the skips are pushed by hand, one at a time, on to the traverser, which transfers them under the elevating conveyor to the opposite side ready to be loaded with spoil. As each skip is filled, it is pushed away down the track, which is on a slight down grade, to a waiting train for hauling to the disposal area.

We were informed that with the equipment described and working over three shifts, the tunnel is being driven forwards a distance some 13ft 6in every twenty-four hours by a face team of about twenty-five men.

When starting a tunnel the brick portal is first completed and made oversize to permit the passage of shield. To provide an anchor against which the shield reaction thrust can be exerted initially a structure of buttressed piles is erected outside the portal. The first few lining rings inserted at the entrance of the tunnel beyond the portal structure are built up from iron segments, which, when they have been rigidly grouted in position, provide the shield anchorage for the subsequent sequence of operations using the precast concrete segments. It is pointed out that the use of concrete lining of this design eliminates the need for fastenings between successive rings and the use of grouting outside the lining of the tunnel.

Placing segments on erection arm behind shield. The arm on the left has been raised by its hydraulic ram to position a set of segments

SHORTER REPORTS

High Polymers and their Physical Behaviour

THE Kelvin Lecture of the Institution of Electrical Engineers was given in London, on February 6, by Dr. H. W. Melville, secretary of the Department of Scientific and Industrial Research. Dr. Melville's lecture was concerned with the chemical structure and physical behaviour of high polymers, and he showed that there was a growing association between electrical engineers who were seeking new materials, and high polymer chemists who were disclosing the possibility of producing man-made materials to fit their special requirements. High polymeric materials, he said, were not specially new, for rubber and celluloid had been discovered in the nineteenth century, but the systematic search for new high polymers for specific uses was a more recent development. Sufficient knowledge had begun to emerge, about the relationship between physical properties and chemical constitution, to enable these matters to be studied with less empiricism than was possible twenty years ago.

Rubbers, for example, exhibited elastomeric behaviour, over a limited temperature range, and there was a need to extend this range. One method of extending the range downwards was to add small molecules to the rubber, as plasticisers or molecular lubricants. A recently discovered method of preventing crystallisation consisted in making a slight modification to the rubber : in the presence of a thiolacid containing the group COSH, the disposition of the groups around the double bond connecting two of the central atoms in the unit of the rubber molecule could be changed. The result was that the regular molecular geometry was disturbed and it then became impossible for the chains to form crystallites. Extending the temperature range to higher limits meant giving the molecules structures altogether different from the carbon backbone and, in fact, it was necessary to consider a backbone of silicon and oxygen atoms in repeating units with various groups attached to the silicon atom (e.g. CH_3). These polymers—the silicones—were, physically, substances ranging from mobile liquids to rubbers depending only on the molecular weight of the molecules comprising them. The liquid members of this series were far more compressible than ordinary liquids, but more extraordinary still was the fact that the viscosities, that is to say the intermolecular forces, were not affected by temperature to anything like the extent of liquids like hydrocarbons. The overall temperature dependence extended the useful range of the silicon rubbers over a much wider range of values than the ordinary hydro-carbon rubbers.

Turning to polyethylene, Dr. Melville said that, when prepared at about room temperature, this substance was simply a linear chain of carbon atoms with hydrogen atoms attached. On the other hand, when prepared at high temperatures (200 deg. Cent.) and high pressures (1000 atmospheres) the molecules had many branches attached to the linear backbone. This difference in structure had important effects on properties. Over a very limited temperature range the specific heat rose to indefinitely large values, showing that the material must melt within a small range of temperatures. The liquid so obtained thus possessed a specific heat similar to that of liquid paraffins. When this liquid was quenched rapidly to room temperature the density of the solid was 0·91. On the other hand, when cooled very slowly to the same temperature, the density was much higher—0·98. X-ray diffraction data showed that the latter material was polycrystalline, the former amorphous. At room temperature the rate of crystallisation was very small. The important point of principle here was that these polymers could thus be subjected to a measure of heat-treatment—in a way similar to that of a metal—so that molecular arrangements could be altered to suit the purpose for which the polymer was required. Probably the most interesting region was around molecular weights of about 10,000, where the percentage crystallinity had a most profound effect on the nature of the product. The final modification that could now be readily made to any variety of polyethylene to increase its melting point almost indefinitely, consisted in exposing it to high energy radiation, such as gamma radiation. One of the chemical changes was that hydrogen atoms were removed from the chains leaving free radicals behind. These radicals joined up to give cross links and they gave rise to a three-dimensional structure which, at high enough temperatures, decomposed rather than melted.

Finally, dealing with man-made fibres, Dr. Melville mentioned ion-exchange fibres which resembled animal muscle in mechano-chemical behaviour. Such fibres could be made to contract when in contact with one type of solution and expand when in contact with another, thus performing mechanical work. This research was at a very early stage, and the actual efficiency of the mechano-chemical system was low—about 1 per cent. No real attempt had yet been made to get the optimum from such fibres for this kind of engine and no doubt a much better performance could be achieved. Dr. Melville pointed out that the first steam engines were not very efficient and even to-day the modern railway locomotive only operated at an efficiency of about 5 per cent.

550MW Boiler for Thorpe Marsh Power Station

THE Central Electricity Generating Board has issued brief particulars of a boiler which it proposes to order from International Combustion, Ltd., to supply steam to a 550MW turbo-generator. The 550MW boiler and its associated generating set is projected for installation in the power station which it is proposed to construct at Thorpe Marsh, near Doncaster. Application has been made by the Central Electricity Generating Board for the consent of the Minister of Power to the establishment of a 1100MW station on this site.

A station of this size will cost approximately £40,000,000, and will require more than 2,500,000 tons of coal a year which will be drawn from a wide area covering the Yorkshire coalfield and the northern parts of the Nottinghamshire coalfield. The quality of the coal will vary very considerably, with ash contents from 6 per cent to 30 per cent and moisture contents from 4 per cent to 20 per cent. Special steps are taken in the design of the boiler to enable this range of characteristics to be accepted.

The 550MW unit itself is designed for a continuous maximum rating of 3,750,000 lb of steam an hour, at a pressure of 2400 lb per square inch and a temperature of 1055 deg. Fah. with reheat to 1055 deg. Fah. after the high pressure stage of the turbine. The feed water enters the boiler at a pressure of about 2600 lb per square inch and a temperature of 496 deg. Fah. at full load.

The boiler has two furnaces, each sub-divided into two sections and fully cooled by water or steam tubes. One furnace controls the main steam temperature and the other the reheat steam temperature. The furnaces are each 68ft wide and 28ft deep and 100ft high. The main drums of the unit are 148ft 6in above ground level. Careful design has been required to limit this height, as in a 200MW boiler the drum is at a height of about 135ft and there is a natural tendency for height to increase with size.

Assisted circulation is employed : all the water-tubes in the furnace and elsewhere are fed at regulated rates by special pumps, the pump motors being water immersed to avoid the necessity of bringing out the moving shafts through the pressure casings.

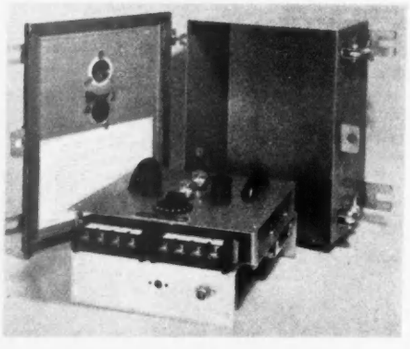
Firing is with pulverised fuel through burners in the corners of each furnace, from which the flames are directed to form a vortex in the centre. There are eight pulverising mills, four to each furnace ; three are adequate for full load, leaving the fourth free for maintenance. These mills have a nominal maximum capacity of 50 tons an hour each.

The boiler will have four rotary air heaters and four sets of fans per unit. Up-to-date mechanical and electrostatical dust cleaning plant will be installed to clean the chimney gases, at a cost of more than 10 per cent of that of the whole boiler plant. The boiler will have a guaranteed efficiency of 90 per cent.

Capacitance-Operated Level Controller

A NEW version of the "Tektor Major" level controller has been produced by Fielden Electronics, Ltd., Wythenshawe, Manchester. Like its predecessor, the new instrument operates by detecting the change in capacitance caused by the proximity of the material whose level is to be controlled.

It consists, essentially, of a capacitance probe which is mounted in a predetermined position on the inside of the wall of the containing vessel. The probe is connected by coaxial cable to the instrument itself which can be mounted some distance away. In operation the proximity of the material in the container, with respect to the probe causes a change in capacitance. This



This level controller detects capacitance changes resulting from the proximity of the material in the container which is under control. All the components are mounted on a removable chassis

change disturbs the balance of a capacitance bridge in the instrument and, at a predetermined level, operates a contactor relay, and lights an indicator lamp. Various control requirements can be met by installations of one or more "Tektor Major" equipments. For example, two sets could be used to give high-level and low-level control in a container. Standard lengths of cable of 6ft, 12ft, 20ft, 30ft and 35ft maximum are available for the high-level instrument and 6ft, 12ft, and 20ft for the low-level instrument. The performance of the instrument is stated to be independent of cable length up to the specified maximum and a cable selector switch is fitted to enable the appropriate cable length to be provided for on site.

The instrument is equipped with calibrated control of the set point. There is a control knob on the front of the chassis, so that the set point can be adjusted on site, and, by noting the reading, the setting can be made repeatable. There are two indicator lamps, one of which is always energised. Operation of the level controller in response to the condition of the capacitance bridge is effected through a con-

tactor relay which has a switching capacity of 5A a.c., non inductive, at 440V and is equipped with two pairs of contacts—one normally open and the other normally closed. A voltage selector is fitted to allow the instrument to be set on site for any supply voltage in the ranges 110V to 125V, 220V to 250V, and 380V to 440V at 40 to 60 c/s. By a quarter-turn slackening of three screws the chassis carrying all the components can be removed from the case, as shown in the accompanying illustration.

Single Geared Rubber Mill

THERE was shipped last week, from the Woolwich Works of Reed Brothers (Engineering), Ltd., a 60in by 22in by 22in single geared mill for delivery to the Apex Tire and Rubber Company, of Pawtucket, Rhode Island, U.S.A. The contract for the mill resulted from close co-operation between several British firms and represents a combined effort to obtain a foothold in the dollar market for this class of machinery. As designed and assembled the machine is completely self-contained and is entirely independent of the need for special foundations. It has been forwarded in one piece, as illustrated, and can be described as a " Packaged Mill " for the unit has only to be placed, in the position as planned, on a normal factory floor, and the necessary electrical and water service connections made, for it to be ready to begin production.

This design is based on the material to be processed and on the requirements of H.M. Factory Department incorporating also the safety recommendations of National Joint Industrial Council No. 1 Mill Committee report. The rolls have been raised to the level required by the Factory Department for safe working and the mill is equipped with the Lunn Principle Sensitive Safety Bars which operate electrical plug braking for emergency stopping. The motor, gearbox and side frames are mounted on a common bedplate fabricated from 15in by 4in rolled steel channel having joints fully interlocked and welded and having welded steel mounting pads which are machined after fabrication. This combination of bedplate and deep side frame is capable of withstanding loads equal to those taken by a concrete foundation 6ft to 8ft deep and weighing between 40 to 60 tons. The bedplate itself is supported upon an adequate number of suitably disposed Vibro-Insulators, which are anti-vibration mountings consisting of vertical rubber cylinders bonded between co-axial steel cylinders and arranged to take a dead load in vertical shear. They are adjustable in a vertical direction on jacking screws so that it is not necessary for the floor to be level.

The rolls are hollow and of heavy duty deep-chilled cast iron with machined and ground bearing and working surfaces. The massive bearing housings are provided with an internal lubricant trap and drain, and double labyrinth grooves on the housing serve to prevent the egress of lubricant and the ingress of powder. A vertical over-lap plate, flush with the roll end surface, prevents endwise spew and thus eliminates the possibility of colour contamination. Lubrication is by a Wakefield mechanical grease pump. The nip is opened and closed by adjustment of the front roll by means of large diameter steel screws working in screwed steel bushes inserted in the cast iron side frames. A single hinged lever operates the large size castellated caps and an alloy steel breaker punch disc, which rotates independently, is attached to the end of the adjusting screw to give positive adjustment of the roll. For safety purposes there is fitted a mild steel breaker plate designed to shear at a predetermined loading.

Power for the drive is provided by a Brook 150 h.p. 550V three-phase 60 c/s slipring motor, having a synchronous speed of 1200 r.p.m. and built to withstand plug breaking. The overload capacity is 25 per cent in torque for two hours, 50 per cent for 1 min. and 100 per cent for 15 seconds. The motor drives through a 20in underdriven fan-cooled worm reduction gear, supplied by John Holroyd and Co., Ltd. The size of the bull pinion is such that it gives a surface speed of 120ft per minute to the back roll and 96ft per minute to the front roll, a friction ratio of 1·24 : 1. Allen West and Co., Ltd., provided the contactor starter consisting of a totally enclosed general purpose metal clad air break contactor pattern, reversing combined stator/rotor starter rated at 15 starts per hour against 100 per cent full load torque. The main components of the starter include a triple pole forward stator contactor, having magnetic blow-outs and providing undervoltage release, mechanically interlocked with a triple pole reversing stator contactor. There are four double pole rotor contactors rated for a maximum rotor current of 250A per phase and a timing relay to control their closing, also three adjustable overload relays with oil dashpot time lags and a control circuit relay. Control of the mill is by a three-way start-stop, inch-reverse push button switch and there is a pilot light connected across the contact in the final rotor contactor, which indicates when the mill is running at operating speed. The limit of the operator's reach for safe working is indicated, and there is a sensitive safety bar carried on suspension arms fitted with balance weights which give a horizontal loading to the bar of about 40 lb. A movement of the bar of less than ¼in operates limit switches, which cut off power and simultaneously apply the brake so that the rolls will come to rest in approximately one eighth of a revolution.

While attending a demonstration of the mill, before shipment, we took the opportunity to inspect progress in the construction of the company's new works on the Woolwich Industrial Estate. An existing building consisting of a bay having a span of 40ft and a length of 380ft has been adapted to the production of new mills and the reparation of old mills. A new shop, adjoining the old and measuring 300ft by 40ft, is nearing completion and will relieve present congestion and make for quicker delivery.

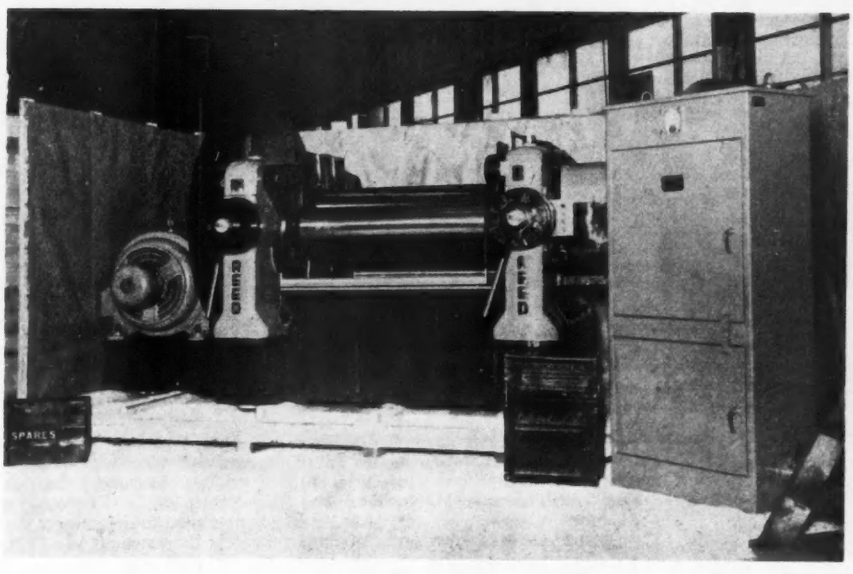
Road Tanker Construction

IT has been found by Thompson Brothers (Bilston), Ltd., that a tank for the bulk transport of liquids, if made in steel, even mild, must be far heavier than the liquid loads require in order that the material thickness shall be practical. The lightest steel tank requires the support of a chassis beneath it, but the relatively high torsional stiffness of the tank is incompatible with the weakness of conventional chassis, and may lead to breakages of the forward part of the frame. If light alloy is used for the tank, a saving in weight results because the required thicknesses are practical ; while the torsional stiffness will be at least as high, in other modes of deflection the tank will be stronger. Thus, instead of calling for a chassis with zero roll stiffness at the front, it is possible to employ a non-redundant tank mounting which does not restrain the chassis.

The form of the tank can be discerned in our illustration. Considering the tank as a beam loaded in the vertical plane, the flanges are pairs of hollow booms at top and bottom of the tank : the webs are formed by a series of verticals welded to the tank bulkheads. Around this elementary structure is wrapped the skin containing the liquid load, which contributes the shear bracing and greatly increases the torsional strength beyond that given by the diaphragms.

Tank under construction : the flanges in the foreground will form part of the hollow booms. To the far side of the dished bulkhead vertical stiffeners are welded to stabilise it

The tank is supported near the rear end by two rubber-bushed joints under the longitudinals and near the front end by a box-section cross-member joining the booms. The centre of this member is joined by another rubber-bushed pivot with a fore-and-aft axis to a short beam spanning the chassis and itself supported at the ends by bushes with transverse axes. Twisting of the frame can therefore be accommodated entirely by the pre-loaded rubber bushes, and does not affect the stresses in the tank : a qualifying condition is that the front balance beam has, between it and the tank structure at each side, a rubber buffer, which places a certain



Rubber mill ready for shipment

damped constraint on twisting of the chassis.

The tank is composed of a relatively high strength alloy supplied by Northern Aluminium and having an ultimate tensile strength of 18 tons per square inch; fabrication is by Argon-arc welding. The first examples are 2000-gallon petrol tankers, divided into four compartments, in which an increase of 200 gallons or more for the same weight has been achieved. The principle has not yet been applied to increase the maximum load, at present about 4000 gallons, on a single vehicle. The initial cost of the vehicle is increased, but this is expected to be recovered rapidly from operating costs, since not only is the vehicle lighter, but painting of the tank becomes unnecessary. A significant advantage is that petrol can be carried in an aluminium tank without internal protection, whereas a mild steel tank would require an expensive lining of, say, " Epikote " resin.

Electrodes for Gouging and Piercing

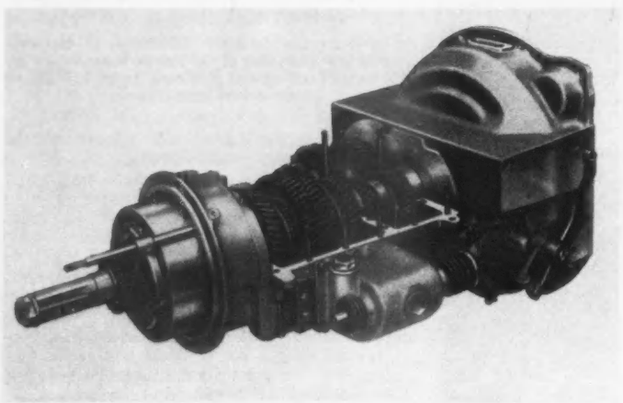
THE welding electrode department of the English Electric Company, Ltd., has introduced an electrode which can be used for cutting grooves, gouging, piercing or removing surplus metal in steel, cast iron and non-ferrous metals. These electrodes known as " Groovees," are supplied in two standard sizes of 10 s.w.g. and 8 s.w.g. They can be used with ordinary a.c. or d.c. welding plant without additional equipment and are stated to leave a clean scale-free surface that requires no further preparation before re-welding. As they contain a steel wire core, carbon pick-up is avoided.

When cutting a groove the electrode is held at an angle to the work surface, pointing in the direction of travel, and, after an arc is struck, is moved rapidly along the line to be gouged. The energy of the arc cuts the groove and removes the molten metal giving a clean bright finish. For gouging out defects in castings a series of overlapping grooves are cut in alternate directions enabling a defect of considerable depth to be removed.

When it is required to pierce holes or remove rivets, an electrode is held perpendicular to the workpiece, the arc struck and held until the metal flows, and then the electrode is moved into the molten pool. It is stated that with manipulation, holes up to $\frac{3}{4}$in diameter can be pierced in plate up to $\frac{1}{2}$in thick, and rivets removed from much thicker plate.

Ten-Speed Transmission

A CLOSE-RATIO two-speed auxiliary gearbox was shown by David Brown at the 1956 Commercial Vehicle Exhibition. In its original form it was not easily mounted on short-wheelbase vehicles, since an extra propeller shaft and two more universal joints were required. The box has now been made available as an addition to an existing five-speed box, the 557, which so modified becomes the 557A. The auxiliary is an epicyclic train with a ratio of 1·375 : it is controlled by a second lever in the cab. On the direct-top gearbox the under-drive gives ratios intermediate between the normal ones. In the alternative overspeed-top model the change between fifth and fourth is only 1·3, instead of 1·8 approximately for the other changes, and therefore the tenth gear is in effect unobtainable. The main gearbox has been modified by increasing the face width of the gears, and the input torque allowable has risen from 350 lb-ft to 480 lb-ft. Both main and auxiliary boxes use the same lubricant, but separate filler and drain plugs are fitted : were there to be a common sump, the great length of the unit would render it sensitive to steep gradients and demand an oil pump.



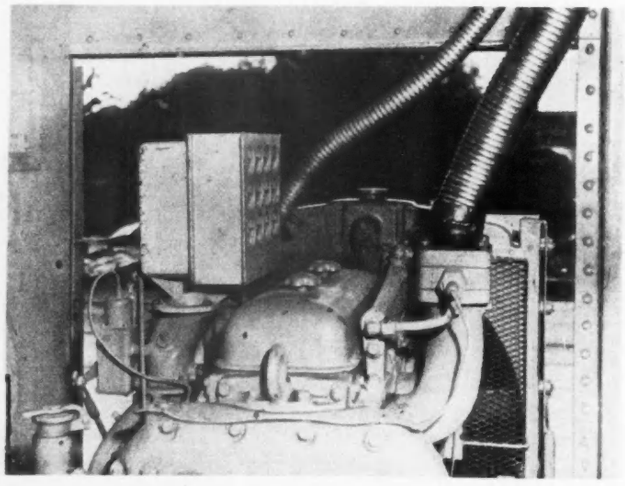
A close-ratio epicyclic train allows nine or ten ratios within a spread of 10·9 to be obtained : two gear levers are employed

Air Cleaning

THE licensed manufacturers in Europe of " Far-Air " products, originating from the Farr Company, of Los Angeles, are Intermit, Ltd., Bradford Street, Birmingham, 5, a Birfield company. These filters are all claimed to allow very low maintenance costs, and in one case, the " Rotonamic," no servicing whatever is needed. The " Rotonamic," which we illustrate, is an assembly of cyclone separators, whirl being instigated by propeller-like vanes at the entry, and clean air leaving through a tube in the centre of each cell, which extends nearly up to the entry : thus the air travels from one side of a bank to the other. The solid matter entrained in the air is separated out and carried away by a bleed of 10 per cent of the total intake air; in the case of engine air cleaners, the depression required to remove this bleed may be available at the exhaust nozzle. The pressure loss for the remaining 90 per cent of the air is rather higher, varying with throughput about a level of 3·5in water gauge. At that pressure drop, which corresponds to a flow of 1000 cubic feet per minute through a 20in by 20in panel, the effectiveness on a dust of specific gravity 2·5 was 99·5 per cent for particles 10 to 20 microns, 95 per cent for 5 to 10 microns, and 75 per cent for 0 to 5 microns ; an even higher performance is recorded on high-density dusts.

The more conventional " Far-Air " filters are viscous impingement designs ; alternate flat and corrugated layers of wire mesh are presented to the stream edge-on, and the channels defined by the corrugations are zig-zag in shape. Thus, in a passage that leads first right and then left, dust will be deposited progressively along the left-hand wall as far as the bend, and then along the right-hand wall. Even when the filter is completely loaded the air passages along the corrugations remain ; thus, the filter can safely be used on intakes for cooling air, for which plugging of a filter would be catastrophic. The filters can be cleaned with water and rendered adhesive with engine oil, and facilities for so doing automatically may be incorporated ; Intermit operate a maintenance service using replacement elements.

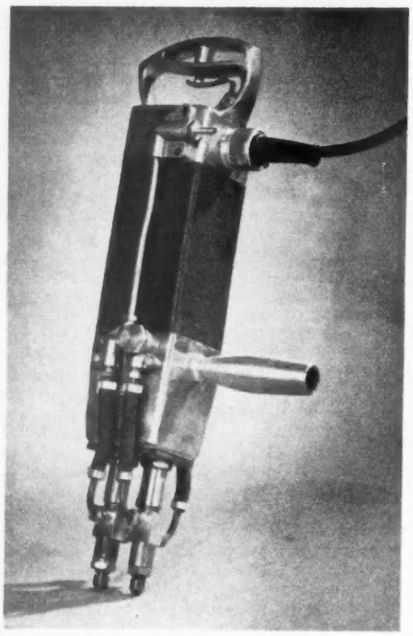
Variants of the labyrinth filter include a second stage of cellulose tissue (" paper "), which is effective against particles up to 10 microns diameter, and also air coolers in which a mesh element is kept continually wetted by rotation through a water bath.



A small "Rotonamic" panel mounted on the air intake ducting of a diesel engine

Welding Gun

OUR illustration shows the " Model DP.36 " welding gun which was recently placed on the market by A.R.O. Machinery Company, Ltd., 190, Castelnau Road, London, S.W.13. This is a development of the " DP.35 Twinspot Welder. "



Water-cooled welding gun for high production rates

As may be seen from the illustration, the new model has been equipped with water cooling which is applied to the electrodes, electrode holders and transformer, and is claimed to increase its rate of operation four-fold over that of the earlier model. Its capacity is 22 to 20 S.W.G. to heavier mild steel sheet. With 22+22 S.W.G. mild steel, a production rate of 2400 spots per hour is stated to be obtainable.

Industrial and Labour Notes

Productivity and Prices

In the January issue of *Bulletin for Industry*, the Treasury issued a statement on the "three things necessary for price stability." It says that the first, which is the Government's responsibility, is to see that the general economic climate is such as will not encourage either cost or price increase. The second condition is the exercise of restraint by trade unions in making wage claims and by business men in fixing profit margins, dividends and prices. The third requirement, it is emphasised, is to keep costs down by improving efficiency, the main scope being in productive industry both public and private. The *Bulletin* points out that the largest sector of the economy is manufacturing. It accounts for nearly four-fifths of industrial output and about two-fifths of the output of all goods and services. It is also the sector in which, because of the nature of its processes, the most rapid advances in productivity can generally be made.

In the last two or three years the trend of productivity in manufacturing has been as follows : in 1953 and in 1954 output per man rose by 5½ per cent, in 1955 it rose, more slowly, by 4 per cent, and in 1956 it fell by 2 per cent. Last year, the *Bulletin* notes, there was some recovery ; in the first nine months there was a gain on a year earlier of around 3 per cent. The restraints imposed on home demand in the interest of currency stability, combined with the failure of exports to rise as fast as those of our principal competitors, are factors which have tended to keep total output steady. With the labour force also showing little change this has meant little improvement in productivity. Thus, the Treasury observes, the good effect of new investment on efficiency and costs has on the whole not yet been felt. But, it is added, even with stable output productivity could have risen faster than it did. If firms generally had concentrated on using their improved capital equipment to the full, the same output would have been achieved with fewer men, and output per man would have risen more. As a rule, firms have preferred to keep their workpeople, for a combination of social and economic reasons and, not least, in expectation of an early revival in demand. The Treasury's comment on this is that it had the effect of inhibiting, for manufacturing industry as a whole, the growth of output per man. At present, the *Bulletin* says, skilled engineering and shipbuilding labour is still short all over the country ; and in important sections of the engineering and iron and steel industries there is, in a few places, a shortage of unskilled labour as well.

There have been some examples of gains in productivity being passed on in lower prices, and, notably in 1956, this was often at the expense of reduced profit margins. But the effect on prices of higher productivity has to a large extent been offset by factors working in the opposite direction. Some raw materials reached high levels during this period, and fuel and transport prices also rose. Above all, labour costs per unit have risen, as the total of wages and salaries in manufacturing has tended to outpace productivity. Manufacturing, however, the *Bulletin* remarks, now has the benefit of lower raw material costs in addition to that of the new investment ; in December, basic materials were on average about 10 per cent cheaper than in April. When material prices were rising, manufacturing industry was more successful than the rest of the economy in partly offsetting the rise by gains in productivity. Now that the cost of materials is falling there is corresponding scope for a fall in the prices of manufactures. Such a fall, indeed, the *Bulletin* concludes, is a condition of stable prices generally.

Industrial Relations

On Thursday of last week, the House of Commons debated an Opposition motion expressing "grave concern" that the Government's economic and social policies, in addition to producing growing economic difficulties, were resulting in serious damage to relations in industry. Many of the speeches reiterated matters that have been raised in similar debates on former occasions. Some of them commented on the handling of recent wage claims and some were critical of the existing machinery for arbitration.

The debate was wound up for the Government by Mr. Robert Carr, Parliamentary Secretary to the Ministry of Labour, who said that, since the war, attempts had been made to do what had never been done before, namely, to achieve at one and the same time full employment, stable prices and free collective bargaining as a method of determining wages. No Government, he added, had succeeded in achieving fully all those three things together. This country had not been alone in facing the problem or in failing to solve it. Experiments in a kind of national wages policy had been made in some countries abroad, but, when the statistics in those countries were looked at, it was found that, at least in recent years, the inflationary trends had been no more restrained than in this country. Mr. Carr said he did not believe that direct state action could solve the dilemma without giving to the Government powers to command the fixing of wages and the movement of labour, which would be intolerable in a free society. Nevertheless, whilst believing in our system of free collective bargaining, he was certain that we could not be complacent about how the present system worked at the moment.

Later in his speech Mr. Carr expressed his belief that it was of great value to get the two sides of industry into the habit of meeting and talking together about problems other than wages. But the growth of good industrial relations, he said, must start at the level of each firm and factory. Good relations at that unit level would, in the end, build up good relations at the national level as well.

European Industry and Trades Unions

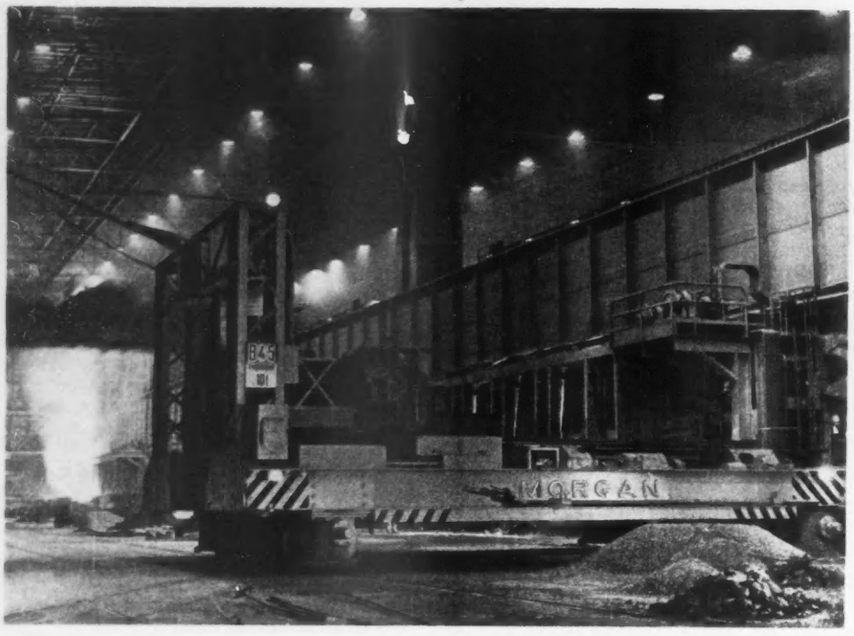
A conference sponsored by the United Kingdom Council of the European Movement, entitled the European Industrial Conference, is to be held at Church House, Westminster, London, S.W.1., on January 19, 20 and 21, bringing together European industry and trades union leaders for discussion of the economic problems resulting from the proposed free trade area. The conference, which will be opened by the Chancellor of the Exchequer, will be divided into four main commissions, for the detailed examination of problems arising from the removal of tariffs and quotas, for social policies, for co-ordination of economic and monetary policy, and for food and agricultural problems. In an announcement issued by the United Kingdom Council it is stated that there will be no formal resolutions but that the conference will be both exploratory and informative. A report is to be issued summarising the different points of view expressed.

The British Employers delegation will be under the chairmanship of Lord Knollys, chairman of Vickers, Ltd., and the Rt. Hon. Alfred Robens, M.P., and leading members of the Trades Unions Congress will organise the labour participation in the conference. In addition to the British Trades Union delegation, leading trades unionists and leaders of industry from Austria, Belgium, Denmark, Eire, France, Germany, Italy, Luxembourg, the Netherlands, Norway, Sweden and the United Kingdom have been invited, together with representatives from Greece, Portugal and Turkey. Monsieur Robert Schuman, president of the European Movement, will also attend the conference.

South Wales Steel Problems

Last week, the Minister of Power, Lord Mills, together with the Minister of State for Welsh Affairs and the Parliamentary Secretary to the Minister of Labour, received a deputation of Welsh Members of Parliament to discuss the effects of closing certain steel, sheet and tinplate works in the western part of South Wales. Various proposals were put forward concerning alternative employment, the adaptation of the mills for other products and the future of the area generally. The Ministers explained that the closures were an inevitable consequence of the concentration of steel production in more up-to-date plants in the area, although the process had been hastened by a falling-off in the demand for the products of the old works. They informed the deputation that a Government team would examine any steps that could be taken to assist workers who had, or would, become redundant.

At the end of the week, the Minister for Welsh Affairs announced that the Government team had been appointed to examine, as a matter of urgency, "further methods of meeting the difficulties raised by the closure of certain steel, sheet and tinplate works in west South Wales and the threatened closure of further works." The members of the team are Mr. F. Blaise Gillie, the Welsh Secretary of the Ministry of Housing and Local Government ; Mr. R. W. Daniels, Board of Trade Controller for Wales ; Mr. B. M. Evans, Ministry of Labour Controller for Wales, and Mr. H. McArthur, chief production officer of the Iron and Steel Board. The team held its first meeting last Tuesday ; its primary concern is to consider what further measures can be taken by the iron and steel industry in the near future to minimise the hardship involved and assist in maintaining employment in the area.



The furnace bay of August Thyssen No. II open-hearth plant houses four 250-ton oil- or gas-fired furnaces. The illustration shows one of the two 10-ton charging machines which have a capacity of 70 tons per hour each

Open-Hearth Plant of August Thyssen-Hütte

Whereas in pre-war days production of sections was predominent at August Thyssen-Hütte, the importance of rolled sheet increased greatly in the post-war period. In consequence, while formerly the production consisted of 73 per cent of Thomas steel and 25 per cent open-hearth steel (the remainder being electro steel), the present-day rolling programme calls for an increase in the open-hearth steel to 50 per cent. August Thyssen-Hütte already had in operation the No. II open-hearth plant, equipped with four 140-ton and two 70-ton furnaces. The company has now at its disposal a second plant, the No. I Open-hearth Works,* which was initially equipped to produce 60,000 tons per month, but is intended for an ultimate monthly capacity of 100,000 tons. Its main characteristics are the installation of four 250-ton furnaces, the charge from each of which is run off into a single ladle, and the use of fuels such as coke oven gas and fuel oil, which have a high calorific value and result in shorter repair times and a high utilisation factor of the furnaces. Special steps had to be taken to ensure the quick delivery of the raw materials, i.e. scrap, pig iron, and flux.

The open-hearth plant comprises five bays: the scrap bay, the bay for assembling and loading the trains of tubs, the furnace bay, the casting bay, and the stripping bay. A 235m long ramp for rail and road vehicles connects with the works' railway and road system.

A main factor in the output from a furnace is the charging rate. With a proportion of 60 per cent scrap in each melt, 170 tons of scrap are required which are brought to the furnace in four tub trains, each 30m long, and charged at the rate of 70 tons per hour, corresponding to a design melting capacity of 25 to 27 tons per hour. Charging is carried out by two 10-ton charging machines. Both the design of the furnaces and the manner of their operation follows current American practice.

Pig iron from the blast-furnaces is fed to a 1000-ton mixer, so that the open-hearth plant is independent of the times of tapping of the blast-furnaces. From this mixer the iron is distributed through launders to the open-hearth furnaces. For fluxing materials, a system of twelve elevated bunkers, totalling 1000 cubic metres has been provided. This is situated about 110m away and is provided with tracks at the level of the furnace stage, so that trains of tubs can be gravity-filled and then brought into the furnace bay.

The furnaces, nominally of 250 tons, give tapping weights of 250 to 270 tons. Their hearth size is about 90 square metres, the mean depth 4·2m. Except for the roof, the lining is basic, the hearth being built according to the Crespi method. The 270mm thick rear wall is inclined at 30 deg. Vaults of furnaces 1 and 2 form a box structure, while those of 3 and 4 are ribbed. Each furnace has two chambers of about 560 cubic metres each, for preheating the blast. Of these, 365 cubic metres are filled with a lattice of refractory brick. In front of the chambers, room has been provided for about 110 cubic metres of slag.

For use in the open-hearth plant the coke oven gas is compressed to 3000mm water gauge. Oil can be used either in the form of mineral oil or tar oil. Altogether four reservoirs of 750 cubic metres each have been installed. After it has been heated to 110 deg. to 130 deg. Cent., the oil is pumped to the burners under a pressure of 7 atmospheres. Atomisation is carried out either by compressed air or by blast-furnace gas preheated to 150 deg. and 250 deg. Cent. respectively. The amounts of both fuel and air or gas are controlled from the control panel of each furnace.

In the casting hall two 375-ton cranes have been installed. For the sake of the improved quality of the product, the whole 250-ton charge is tapped into one ladle and cast into ingot moulds carried on bogies. Each bogie can take four moulds so that for each tapping nine to ten bogies are required which constitute a train of just over 50m length. For casting, two 60m long platforms are available.

Ingots are transferred to the stripping bay where the moulds are stripped by two 40-ton cranes, and are then transferred to the distributing point in the pit furnace bay. All rail tracks in the plant are made in standard gauge.

Compared with the older No. II plant, the new plant requires considerably less personnel. While No. II employs 530 men in three shifts to give a monthly output of 35,000 tons, the new No. I plant produces 60,000 tons of steel with 270 workers working a four-shift system.

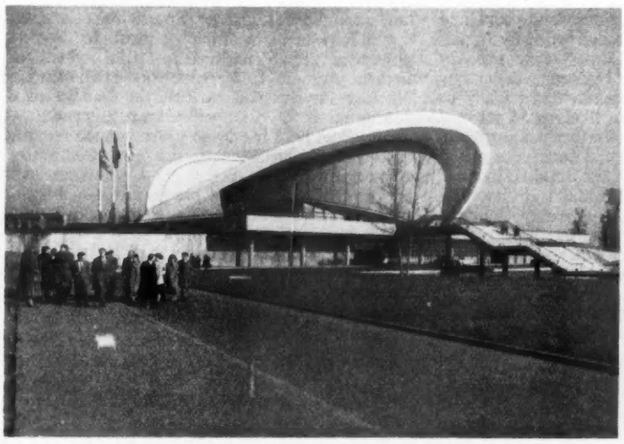
In the construction of the installations for the four furnaces, their buildings, the bunkers and the ramp, 228,000 cubic metres of excavations were required, followed by the placing of 47,000 cubic metres of concrete, using 3000 tons of reinforcement rods, and the erection of steel structures totalling 29,000 tons. Some 10,800 tons of refractory brickwork were laid. Construction, which was preceded by seven months' planning, occupied from October 1, 1955 until September of last year when the last furnace was put into service.

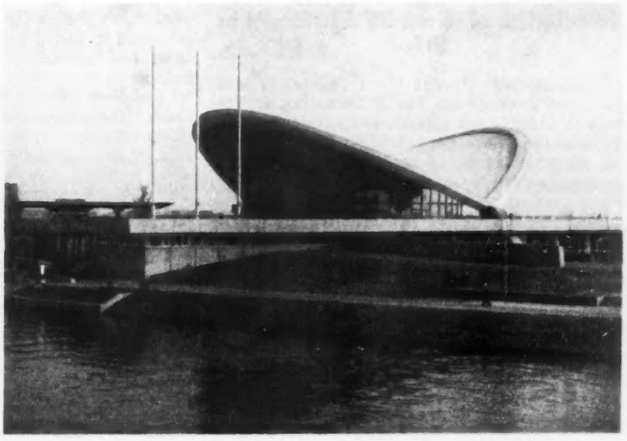
* THE ENGINEER, November 8, 1957, page 685.

First Brazilian Oxygen Steel Works

In its Monlevade steel works, the Companhia Siderurgica Belgo Mineira recently put into operation an oxygen steel plant, the first of its kind in Brazil (see illustration). By this inauguration the capacity of the plant, which is the second largest in the country, will be increased by 200,000 tons annually. Design of installations and equipment lay in the hands of Gutehoffnungshütte Sterkrade Aktiengesellschaft, which supplied the 30-ton converters and the major portion of the materials handling and ingot casting equipment. The process is the well-known "LD" method, in which the iron is converted into steel by a blast of pure oxygen. Since 1952, Gutehoffnungshütte delivered a number of "LD" converters, among them the three original 30-ton converters for starting the process in the VOEST steel plant at Linz, Upper Austria. Two 60-ton converters have been delivered to the Ijmuiden steel works, and more of this size are under construction.

Two "LD" converters of 30 tons capacity each, for Monlevade steel works





Figs. 1 and 2—(Left) Berlin Congress Hall, showing the staircase at the southern entrance. (Right) Berlin Congress Hall from river side (north-west), showing the two roof arches and one of their supporting piers

Berlin Congress Hall

Important aspects of the rebuilding of Berlin were shown at the "Interbau" international building exhibition, which was held in that city from July 6 to September 29 last. Apart from the industrial section, which opened from September 14 to 29 at the Funkturm exhibition grounds, the main theme was the rebuilding of the Hansa quarter which formerly housed 6000 people, but was completely razed during the war. For the replanning of this area, sixty-three well-known architects and landscape gardeners from Germany and abroad were invited, who worked under the overall direction of a committee. The Hansa quarter contains dwellings of every kind, from the single-family house to multi-storey blocks, with intervening green spaces and gardens. Since the houses were at all stages of construction, visitors to the exhibition were able to obtain a particularly detailed impression of present-day methods in the German building industry.

Among the buildings erected in connection with the "Interbau" exhibition, and of particular interest on account of its unusual design, is the Congress Hall at the northern end of the Tiergarten. Situated on an 11-acre site near the River Spree, the hall was presented by the Benjamin Franklin Foundation. It was designed by the architect Hugh Stubbins, Cambridge, Mass., and built by him in co-operation with the Berlin architects Werner Düttmann and Franz Mocken. The building is characterised by the two large arches from which the auditorium roof is suspended. The central auditorium is the dominant portion of the building, overtopping the raised platform by 18m. In the flat-roofed part of the building below the level of the auditorium are situated a number of ancillary rooms and offices.

Because of its situation between a road and the river, the building is accessible from both. Our first illustration shows the Zeltenallee façade, where a short road leads to the entrance staircase over an ornamental pond. On the other side is a landing stage for those who arrive by boat and a flight of steps leading up to the hall, which is situated on artificially raised ground (Fig. 2).

Access is also provided from the two remaining fronts from the car park on the eastern side and a part of the Tiergarten on the opposite side.

On the ground floor are situated reception and exhibition halls, conference rooms, a restaurant, administrative offices and other rooms. Over a staircase one reaches the first floor level from where access is obtained to the 1036 square metres main auditorium for 1260 people, and to the 5388 square metres roof terrace.

The two arches which support the roof of the auditorium run in an east-westerly direction and are also inclined to north and south respectively. Their combined ends rest on two inclined piers, which measure about 7m by 3m at ground level and are of tapering section. The span of the arches is 110m, and they rise to a height of 18m. At the crown, their distance apart is 64m. They have a largest section of 2m by 2·5m and support a 7cm thick prestressed concrete shell roof, which overhangs the terrace by up to 8m.

Site preparations included clearing the ruins of the former "In den Zelten" quarter. Excavation of 25,000 cubic metres was carried out to obtain a level for piling operations, which were rendered necessary by the boggy nature of the subsoil, and for which 740 reinforced concrete piles of 8m to 12m length were employed, as well as 260 "Franki" piles of 40cm diameter and 10m to 13m length. Depending upon the load, bundles of three to six piles were combined by reinforced concrete heads. "Franki" piles of 100 tons capacity were employed at the supports of the main arches and under the auditorium.

The building is erected on a raft of diagonally reinforced, 15cm thick concrete slabs placed between concrete beams. Altogether, 13,000 cubic metres of plain and reinforced concrete were placed, of which 3000 cubic metres were used for the auditorium and its supporting arches.

Professor Ernst Heinkel

The death occurred in Stuttgart on January 31 of Professor Dr. Ernst Heinkel, the aircraft designer and manufacturer. Professor Heinkel was born on January 24, 1888, in Grunbach/Remstal, and received his higher education at the Stuttgart Technical University. In 1910, while still a student, he built his own aircraft and was injured the following year when it crashed. By 1914 he had become chief designer and technical director of the Hansa and Brandenburgische Flugzeugwerke, and during the first world war was responsible for some thirty designs of aircraft. He founded his own firm after the war, which, between 1922 and 1945, produced some 100 different aircraft. In June, 1938, a single-engined "He.112U," piloted by Ernst Udet, flew at over 400 m.p.h., and in April, 1939, an improved machine of this design broke the world speed record at slightly over 463 m.p.h., although this was surpassed within a month by a Messerschmitt "109R" doing 469 m.p.h. Dr. Heinkel was the first to introduce catapults. After testing a rocket aeroplane in 1938, by August, 1939, he had the first turbo-jet aircraft, the "He.178," flying without knowledge of the German Air Ministry, according to a statement he made in 1951. Among the best-known Heinkel aircraft from the last war were the "He.111" bomber and "He.162" fighter.

ECSC Housing Progress

On December 4, the handing over took place, in the mining district of Oberaden (Ruhr), of the 10,000th workers' house so far built in the Community with the financial aid of the High Authority. The house has three bedrooms and a bathroom on the first floor, and on the ground floor a large living-room with terrace, another bedroom, and a kitchen.

By the beginning of 1959, the High Authority's various housing programmes will have made it possible to start work on building 38,000 workers' houses in the coal and steel-producing areas of the Community. This total comprises two programmes to which the High Authority contributes by raising loan funds at low interest rates and two experimental programmes to which the High Authority contributes a direct grant as well as credits.

For the first programme, covering some 15,000 houses, the High Authority raised loans in Belgium, France, Germany, and Italy, totalling 25,000,000 dollars. For the second programme, expected to cover some 20,000 houses, the High Authority is advancing 15,000,000 dollars out of its own funds at a nominal interest rate; this sum will be raised to 30,000,000 dollars by funds to be raised on the capital markets of the Community's member states. The High Authority's contribution will enable a very low average interest rate to be charged.

By December 4, 1957, the High Authority had contributed to the financing of 26,000 houses, of which 11,000 are being bought by their occupiers and 15,000 will be rented. By the same date 10,000 houses had been completed, 11,000 houses were under construction and a further 5000 were in the planning stage.

Second "Atoms for Peace" Exhibition

Under the title "Atoms for Peace" the second International Exhibition of the peaceful uses of atomic energy is to be held in Geneva from September 1 to 14, during the United Nations Atomic Energy Conference. The Swiss Federal Council, the State Council of Geneva and the Administrative Council of the Canton of Geneva are giving their patronage to this important exhibition, which will be organised by a recently constituted non-profit-making body. The latest date for reserving space has been fixed as March 31, 1958, and already more than 11,000 square metres, it is stated, have been booked, of which British industry alone will occupy an area of over 4000 square metres, divided between fifty and sixty firms. The general secretariat of the exhibition is at Place du Lac 1, Geneva (telephone 25 13 00).

Aachen Machine Tool Colloquium

It is announced that the Ninth Machine Tool Colloquium will be held on May 29 and 30 in the large auditorium of Aachen Technical University. The colloquium is being organised by the Faculty for Machine Tools and Production Management (Professor Dr.-Ing., H. Opitz), together with the VDI section "Betriebstechnik." The round table discussions, which will in each case be based on a general report, will be on the following themes: cost structure as the basis of investment planning; adaptation of the machine tool to the problem of production; construction elements for controls of machine tools; research reports from the field of cutting operations, and about measurements on machine tools.

Association of German Engineers in 1956

In its Annual Report for 1956, which was published recently, the Verein Deutscher Ingenieure (V.D.I.) recalls the Association's centenary celebrations which were held in Berlin during the period May 12–15 of that year, with the attendance of 4000 members and guests. The V.D.I. reports an increase in personal membership of 2439 (7·8 per cent) during the year. With nearly 34,000 members, it has now again reached its pre-war membership figure. The sociological questionnaire sent out in November, 1956, was answered by 24,000 members (71 per cent). Results will be reported in detail shortly.

The report lists five main V.D.I. divisions and nineteen technical groups. The main divisions deal with questions of professional standing and general problems, education, the relationship between technology and society, history, and legal and patent questions, while the technical groups each look after a specialised sector of engineering science and technology. Among the chief problems which were dealt with by *ad hoc* committees were the sociological investigation already referred to, problems connected with the position of engineers in public administration and in the armed forces, and technical education. The educational committee took part in the work of the Conference of Representatives from the Engineering Societies of Western Europe and the United States of America (E.U.S.E.C.), which at present is compiling data for an international survey dealing with the training of engineers. An important memorandum was published, dealing with the need to expand the technical colleges and universities; this had caused widespread discussions in the Laender parliaments, from which it is hoped that improvements will soon result. The group "Man and Technology" held four special congresses in different towns and had appointed a number of sub-committees which would discuss the questions raised with philosophers, teachers, sociologists and theologians, before another congress would be held. The Legal Group would continue to press for the recognition of technical lay judges in patent cases, as opposed to the provisions of the new draft law dealing with the functions and training of the judiciary.

Among the Association's publications may be mentioned the newspaper, *V.D.I.-Nachrichten*, which reached a new maximum at the end of the year with a circulation of 56,000. The series of articles "100 Years V.D.I.—a Century of Technology," was concluded. In March, 1956, the paper also began a survey of radio and television programmes which are of interest to the engineer. The journal *V.D.I.-Zeitschrift*, which issued a special centenary number, reached a total of 2000 editorial pages, a figure which had not been attained since World War I. Since the end of 1956, this journal has published quarterly reviews of the preceding year's developments in a variety of technical fields. The monograph series V.D.I.-Forschungshefte published twenty-two papers dealing with a wide range of topics.

Co-operation with other organisations took place in many fields. Of particular importance was the formation of a nuclear working group in Frankfurt/Main, to which twenty-eight technical-scientific associations belong. The Working Group for Noise Abatement (D.A.L.) held an international congress in Munich in October.

Federation of French Industries

On the occasion of its recent twenty-fourth general meeting, the Conseil National du Patronat Français has published the reports of its economic and social committees. The economic report presented a detailed analysis of the situation. Over-expansion of industry was not, it was stated, the root cause of the country's difficulties. This was proved by a similar expansion in Germany taking place without grave effects. Rather was it the conduct of affairs by the State which had hindered progress. It had become a habit of the firms to anticipate the fruits of expanded production. While industrial production during the previous four years had increased by 28 per cent, credits voted by Parliament had increased by 35 per cent, treasury receipts by 30 per cent, and budgetary deficits by 50 per cent. Public expenditure was likely to reach 6100 milliard francs in 1958, or 56 per cent above that of 1954, which, together with expenditure by local authorities would constitute a sum equal to nearly one-third of the national income. The C.N.P.F. strongly expressed the view that the present combination of a partly free and partly controlled economy was unworkable, and that unless a return to liberal conditions took place, the trend to total state control would prove irresistible.

The Social Commission's report recalls the fact that this is the first year in which the Common Market is in being, and that economic facts such as the pressure on wages and salaries must be seen in this light. The Government, having had to adopt a policy of wages restraint, had multiplied its legislative effort in other directions, some affecting the basis of industrial management. Labour shortage had continued; over 115,000 Italian and Spanish workers had been introduced last year, together with about 15,000 Algerians, and over 10,000 Moroccans and Tunisians. Working hours later in the year had reached a new post-war peak with 46 h 1 min. Plans for large-scale wage claims by certain unions had failed. The law of July 26, 1957, had extended the field of mediation in wage disputes. Increases in the cost of living had worsened the shortage of labour after it had been showing signs of easing. An important move had been made in September to achieve a national agreement, by which the C.N.P.F. would recommend the inclusion in wage agreements of the principle of a guaranteed quarterly wage and a more general tying of salaries to increases in productivity. In return, the unions would have undertaken to abstain from wage claims until the middle of March of this year, and various social measures were to have been passed by the Government. This proposal was rejected by the employers. The main problem for the future, the report concluded, was the training of adequate numbers of skilled workers.

European Organisation for Nuclear Research

At its Ninth Session in Geneva on December 19, 1957, the Council of C.E.R.N., the European Organisation for Nuclear Research, elected Mr. François de Rose (France) as its President for 1958. In compliance with the terms of the Convention, which limits tenure of office to three successive years, Mr. de Rose succeeds Sir Ben Lockspeiser, who has presided over the governing body of C.E.R.N. since October, 1954. Mr. J. Willems (Belgium) and Professor W. Heisenberg (Germany) were elected vice-presidents, succeeding Mr. F. de Rose and Professor Holtsmark (Norway). Professor E. Amaldi (Italy) assumed the chairmanship of the Scientific Policy Committee, succeeding Professor W. Heisenberg. Chairmanship of the Finance Committee was taken over by Mr. J. H. Bannier (Netherlands), in succession to Mr. J. Willems (Belgium).

The council approved total contributions from the member states for 1958 of 56,000,000 Swiss francs. At the same time the council agreed that the contributions for the two years 1958 and 1959 should be fixed at a ceiling of 100 million Swiss francs.

Whilst 1957 was the year of peak building activity, 1958 will see European scientists launch a nuclear research programme with the first of C.E.R.N.'s two big accelerators, the 600MeV synchrocyclotron. A long-term programme of research will be carried out.

Assembly of the accelerator components in the recently completed buildings of the 25GeV proton synchrotron—known as the "Eurotron"—will start early next year. The proton synchrotron is expected to come into operation in 1960. Experimental physicists, in collaboration with C.E.R.N.'s Theoretical Division, have started preliminary work on the preparation of a suitable research programme. A special section consisting of both experimental and theoretical physicists has recently been set up to investigate new principles of high energy particle acceleration.

C.E.R.N. will again play host to nuclear physicists of all nations in 1958, when the Eighth Annual Conference on High Energy Nuclear Physics will be held in Geneva as a continuation of the well-known international conferences held for seven years in succession at the University of Rochester in the United States. Invitations to the C.E.R.N. Conference will shortly be sent out to physicists of C.E.R.N. member states and others, including the United States and the Soviet Union.

During 1957 the entire staff of C.E.R.N. moved into its permanent headquarters at Meyrin near Geneva. The total number of personnel is now 598, of which about two-thirds are scientific and technical.

AGARD Combustion and Propulsion Colloquium

The Combustion and Propulsion Panel of the Advisory Group for Aeronautical Research and Development, NATO, will hold its third colloquium in Palermo, Sicily, during the period March 17 to 21, 1958. In contrast with the programmes of the two previous colloquia sponsored by the former Combustion Panel at Cambridge in 1953 and at Liège in 1955, this meeting will be largely devoted to consideration of current propulsion problems. Speakers will include Dr. Theodore von Karman, chairman of AGARD, and Professor J. Ducarme, chairman of the panel. It is expected that between 200 and 300 scientists and engineers from most of the NATO countries will participate in the five-day technical meeting, providing a balanced representation from governmental, military, educational and industrial organisations. Leading NATO scientists in the combustion and propulsion field will present a total of eighteen invited papers during the morning sessions, to be followed in the afternoon sessions by prepared comments from forty-five selected reviewers. It is planned to publish the invited papers and appropriate comments soon after the meeting under the title "Selected Combustion and Propulsion Problems, 1958."

Five themes will be developed during the meeting, with one day devoted to each, namely "Power Plant Requirements Related to Aircraft Mission"; "Interaction of the Combustion Systems with Other Engine Components"; "Noise"; "Combustion," and "Aerophysical Chemistry."

Belgian Electrical Equipment for Finland

An important order for electrical equipment has been placed in Belgium by the semi-public Finnish electricity undertaking, Imatran Voima OY. The order includes four single-phase auto-transformers of 105MVA each, for stepping down a voltage of 400kV to 220kV. In addition, there will be supplied five shunt reactances of 60kVAr, 20kV, which are to be used for compensating the capacity of the line. This brings the total transformer capacity supplied to Finland by Belgian enterprises during the last ten years to 1500MVA. Finnish demand for electricity last year amounted to 8000 million kWh, of which 6500 million kWh were supplied by hydro-electric stations. Many of these are situated in Lapland, away from the centres of population in the south. Transmission is by 220kV lines, to which have recently been added supergrid lines at 400kV, which are connected with the old lines at a number of points. One of these is Pikkarala, on the Oulu River, near its mouth on the Gulf of Bothnia. Another is at Hyvinkaa, not far from Helsinki.

The Belgian transformers are destined for the first-mentioned station, and will form a three-phase group of 315MVA, 400kV, with one reserve unit. Two of the five reactances will also be installed there, the three others are for Hyvinkaa.

At the works of the maker, ACEC, of Charleroi, the transformers are to be tested to 1,650,000V.

The American Scene

BY OUR AMERICAN EDITOR

An American Satellite

Four months have passed since the rise of the first Russian "sputnik" with all the military and psychological implications that so deeply damaged American prestige in the world. Three months have passed since Moscow compounded the blow with the launching of the bigger satellite carrying a dog. Two months have passed since the failure of the United States to put up a small satellite of its own. Now, at last, this chapter of complete American frustration is ended. Up from Cape Canaveral in Florida there rose on January 31 the first American satellite, called "Explorer." It is expected to orbit for months, in testimony that the Soviet monopoly on outer space has been broken. With a weight of 31 lb, "Explorer" is far smaller than either of the "sputniks," and the "souped-up" rocket that launched it is puny compared to the mighty intercontinental missile that placed its Russian counterparts in orbit. Unquestionably, the Russians will hold for some time the military and technological lead thus signified, and it would not surprise Washington if they proved it soon by orbiting a still larger sputnik. Nevertheless, "Explorer" provides a psychological shot in the arm that the U.S. has badly needed at home and on the international scene.

The American programme to put a man-made satellite into orbit around the earth was announced with fanfare in July, 1955. At a White House news conference the scientists in charge of the programme revealed that the American satellite effort would be made during the International Geophysical Year starting in July, 1957. A few months earlier the Soviet Union had disclosed its satellite programme. The Russians made it clear that they were putting top priority on this venture into space. They indicated that it was closely tied to their military rocket programme. The United States, however, took the position that its satellite programme was "strictly scientific" and that this country was not engaged in a "race" to see who could get the first satellite up. Accordingly, the U.S. assigned a low priority to its satellite effort and separated it from military rocket programmes then under way. The U.S. Navy, which was then the only service not working on a long-range military missile, was put in over-all charge of the satellite project—named "Vanguard"—and given a shoe string budget for it. From 1955 on, the United States freely disclosed details of its progress on its satellite programme. Soon after the I.G.Y. began last July, the U.S. announced a timetable under which it would launch a miniature 4 lb Vanguard in November and its major satellite—a 21 lb fully instrumented sphere—in the spring of 1958. The Soviet Union, after announcing its satellite project in 1955, said almost nothing about progress. The first substantial word from Moscow was a stunning announcement: "The first satellite was successfully launched in the U.S.S.R. on October 4." A month later the Russians put up a much bigger satellite which carried a live dog. The Russian achievements stunned Washington. "Most of us did not anticipate the intensity of the psychological impact upon the world of the launching of the first earth satellite," President Eisenhower said, Washington was deeply disturbed by the clear evidence the "sputniks" gave of Russian superiority in rocketry. The United States accordingly stepped up its military missile programme and also pulled out the stops on the satellite programme. The U.S. Army was brought into the satellite programme and was ordered to use a tested rocket—the "Jupiter-C"—to put up an artificial moon. The President announced that the U.S. Navy would attempt to launch the miniature Vanguard in December. All during the first week of December tension built up as American officials gave a step-by-step account of preparations for the Vanguard launching. Then, on December 6, Vanguard was fired. It rose a few feet—and exploded. Since the humiliating failure of Vanguard, the Navy and the Army have been trying to retrieve the situation in some degree by getting one or the other of their satellites up. In mid-January officials at the missile test centre on Cape Canaveral scheduled another Vanguard firing. The Navy took pains to emphasise that it was a test and that there was only "a small possibility" that the miniature satellite would go into orbit., The Navy and officials at Canaveral also took pains to avoid advance publicity. Thus it was not known publicly until January 26 that Vanguard crews had been trying for four tense frustrating days to get their rocket up. At first, bad weather delayed the firing. Then mechanical troubles developed. Vanguard twice came within seconds of being fired, but each time the pre-flight "count-down" had to be stopped and set back to an earlier stage. Then the test had to be suspended pending replacement of the second stage of the three-stage rocket. The spotlight then turned to the U.S. Army and its Jupiter-C. This rocket is an adaptation of the "Redstone" ballistic missile. One of the earlier versions of the Jupiter-C had the best recorded performance of any American rocket. The satellite-launching version of Jupiter-C consists of four stages. The first is a modified Redstone. The second is a ring of eleven scaled-down versions of an Army tactical missile, the "Sergeant." The third stage is a ring of five more scaled-down Sergeants. The fourth stage is the satellite—a bullet shaped unit consisting of a final Sergeant and an instrument package. The part of the first stage is to propel the upper stages to orbiting height. The Redstone burns until the assembly is about 50 miles above the earth. The first stage drops off and the upper stages coast up to about 300 miles. Then the upper stages are fired to give the satellite the speed needed to place it in orbit. Finally, an operator on the ground pushes a button which releases the satellite from the other upper stages.

The U.S. Army brought its Jupiter-C to Cape Canaveral late in December. After a month of preparation, it was ready for the count-down late in January. But strong winds blowing 8 miles up over the Cape forced postponement. Conditions then improved and the firing was set for Friday evening, January 31. The count-down proceeded steadily until 45 minutes before firing time—"X-minus 45." There was a short "hold" while crews checked what looked like a leak from the Redstone's liquid propellant but proved not to be. The count-down was resumed. At Time Zero, 10·48 p.m., a crewman in a blockhouse pressed a button. Slowly, the rocket lifted off the ground. It gained speed, disappeared momentarily in an overcast, appeared again, and finally, looking like a tiny spark, disappeared into the night. Seven minutes later a large computer in Washington, which had been assimilating information about the Jupiter-C from tracking stations along its south-easterly course over the Atlantic Ocean, indicated that the satellite had gone into orbit. The instrumentation of the American satellite includes radio transmitters and devices for measuring temperature, cosmic rays and the frequency of meteorite particles. The radio transmitters convey the information from the measuring devices by means of telemetering. The information from these transmitters is picked up by a dozen "minitrack" stations scattered around the earth. Officials have predicted that the higher-powered of the transmitters—which can be heard by anyone on a frequency of 108·03 Mc/s—will last for two or three weeks. The second transmitter probably cannot be heard by amateurs and is expected to last two or three months because it uses less power. On February 5, the Navy's Vanguard was at last fired—and failed.

Where does the United States now stand relative to Russia in missiles competition and the conquest of outer space? The 31 lb satellite is a dwarf compared with Sputnik I and Sputnik II. Moreover, the rockets that put the Soviet satellites up were correspondingly more powerful than the Jupiter-C vehicle. The latter had an initial thrust of 75,000 lb. American scientists have estimated that the rocket for Sputnik II must have had an initial thrust in excess of 250,000 lb. Coupled with earlier reports that Russia had successfully test-fired an intercontinental ballistic missile, the Soviet satellites produced grave concern in the United States over the possible distance of the Russian missile lead. The exact size of the lead is still a matter of debate and controversy. The U.S. last month successfully test-fired the first stage of its "Atlas" I.C.B.M. which is designed for a range of 5000 miles. On the other hand, at a press conference last week, Dr. Wernher von Braun, the technical director of the U.S. Army Ballistic Missile Agency, said he saw no reason to revise his estimate that it would take five years for the United States to overtake Russia in the missile and satellite art. "Let's remember that Sputnik II had 1120 lb of pay load," he said. "What we have in orbit now is only a rival in spirit to Sputnik." Other American military experts have emphasised that for the immediate future, it is the Strategic Air Command armed with atom and hydrogen bombs, and not missiles on which the United States must rely as the chief deterrent to a Soviet attack. For the long-range future, much depends on the outcome of the debate now in progress on means for speeding and expanding missiles development and scientific education and the overall defence programme.

There was no doubt, however, that the successful launching of an American satellite had a strong psychological impact. The United States had finally answered Khruschev's taunting invitation to "join" Russia in space. A nerve-wrecking period, during which the American failure to get a satellite up reached the proportions of a national humiliation, was over at last.

Detroit in 1958

THE first fact facing the new-car buyer in 1958 is that American car prices have gone up again—on the average by about 100 dollars. This figure applies to the bare car; a lot of the "optional" equipment—power steering, automatic transmission, and similar items which, in 1958, have become virtual necessities for the latest lot of road locomotives—also has gone up in price. If he seeks no more than a simple and economical means of transport, the buyer's choice among the eighteen makes of American cars is restricted to five or six basic models of the approximately forty lines being made to-day. The majority of the 1958 models have been conceived for motorists who may wish to glory in the speed, acceleration, lowness, and "sculptured" length, as well as the prestige and glitter of their cars. All of these characteristics, viewed as a trend, have been accentuated in the 1958 models, though there are a small number of exceptions. As regards engine size, or piston displacement, all surviving six-cylinder engines remain unchanged; however, the displacement of the smallest V-8 engines available with the so-called "low priced three" cars, has been increased, thus reinforcing the development of what has been called "the classless car"—the same size inside for nearly all cars regardless of price. Not since 1934, when "knee action" or independent front-wheel suspension, swept the industry, has a new suspension been as unanimously embraced as air suspension in 1958. The current air suspension systems have three factors in common: all have a bellows at each wheel, replacing the usual spring and containing air under pressure. As the wheel moves up and down when the car hits a bump, a piston in the bellows increases or decreases the pressure of air in the bellows, which acts as a spring. Each system has an engine-driven air compressor and an air storage tank to add air to the bellows as needed. And each system is designed to level the car automatically by pumping air into or exhausting air from the bellows as the load in the car is increased or decreased. The industry's adoption this year of four headlights per car as standard equipment is even more general than the adoption of air suspension. The new system is designed to provide a superior lighting pattern, and does—if all four lamps are aimed correctly. If not, the amount of glare they produce is simply increased. What effect the industry's agreement of last summer to de-emphasise the power and speed of its cars eventually will have, one cannot tell; the present fact is that a great many of the 1958 models can be purchased with a lot more of both than their predecessors. More powerful, bigger-displacement engines are offered as standard or optional equipment for Ford, Chevrolet, Plymouth, Pontiac, Dodge, De Soto, Mercury and Lincoln. With regard to the size of their bodies, American cars have not stopped growing either. The 1958 Chevrolet is 9in longer than the 1957 model and 4in wider. Various Pontiacs are longer by up to 9in, depending on the model. Buick's new "Limited" model is 8in longer than the "Roadmaster 75" on the same wheelbase—and the latter, along with other Buicks, is itself up about 4in in length over last year. The new Rambler "Ambassador" is refreshing, though—it is 9in shorter overall than last year's Nash "Ambassador." Increasingly in recent years, styling has taken on a most disturbing aspect in the American automobile industry. Above everything else, it is being relied upon to sell cars, because engineering no longer seems to make or mar a vehicle's success with the public. Many American makers apparently want their potential customers to forget that any car is a vehicle, and that outstanding vehicles have no obligation to be good looking, though they often are. In the 1958 market, for example, it would be a mistake to assume that, because the Chrysler Corporation cars have not changed their successful 1957 styling, there are no improvements, even if only minor ones, in the new models. Equally it would be a mistake to assume, if it seems that Oldsmobile or Buick styling has gone from bad to worse in 1958, that the new models have no mechanical virtues as vehicles, which they have.

To the surprise of the body stylists, the showroom salesmen and the "hidden persuaders" of Madison Avenue, the American public this year is proving alarmingly indifferent to the lure of Detroit's sleek, powerful—and increasingly costly—models. Contrariwise, with growing enthusiasm it is turning to the small, unadorned but economical vehicles offered to-day chiefly by one domestic and a host of foreign manufacturers. After a decade of requiring more and more chromium-plated ornamentation, the automobile for many again has become no more than a means of transport, a matter of dollars and cents. This dramatic shift has been in the making since 1955, when the Detroit industry, sparked by heavy demand, progressively easy credit and a hot race between two of the "Big Three," rolled out and sold a record-breaking 7,000,000 units. During the past two years, however, the going has grown rougher. Thus in 1956, while business as a whole was surging to fresh peaks, automobile sales declined to less than 6,000,000. Last year brought no pick-up. Automotive circles, to be sure, tended to blame the lag on the excesses of 1955; when the new models came out, so the reassuring forecasts ran, paid-up owners of shabby 1955 motor-cars would flock to buy. Unhappily, these high hopes have been dashed. Far from spurting since early autumn, when the 1958 models were unveiled, sales, if anything, have fallen off. As a consequence, production of most makes now is running well behind previous estimates, as well as last year's results.

Thus, for the first time since World War II. much of Detroit apparently has run out of petrol. Its plight, however, has not been shared by Birmingham, Dagenham, Paris and Wolfsburg, where the Austin, English Ford, Renault and Volkswagen are assembled. On the contrary, manufacturers there and elsewhere have been kept busy turning out small, inexpensive cars for a U.S. market which is growing by leaps and bounds. To illustrate, in 1955 fewer than 60,000 foreign cars were sold in this country. In 1956, sales jumped to more than 95,000 and last year, despite the lull in demand, the figure well may have doubled. Nor can the influx be viewed as a hit-and-run affair. From their permanent beach-heads in the big coastal cities, the importers lately have been fanning out into the most remote hinterlands. Indeed, the distributors of one foreign car, the Volkswagen, have achieved what might be considered the ultimate accolade of American commercial success—they have been charged with violating the federal anti-trust laws. The shift in consumer preference, moreover, shows signs of rewarding the only domestic maker (the American Motors Corporation) which has staked its entire future on the cheap car. The company, which once turned out a full line of Nashes and Hudsons, now produces only the Rambler, with a wheelbase—and a price tag—well under those of any other U.S. model. Spurred by the mounting popularity of all small cars, the sales of the Rambler and its imported counterpart, the "Metropolitan" made by Austin, have risen sharply. Just recently, American Motors took the wraps off the Rambler "American," a new and even smaller vehicle. By sometime in the 'sixties, its president boldly predicts, the small car will have captured half the American market. Be that as it may, Ramblers and foreign cars combined to-day account for over 5 per cent of total U.S. volume, a figure which might be expected to interest the "Big Three." Indeed, the latter have become increasingly interested. Both General Motors and Ford, which happen to be large producers of small cars in Great Britain and on the Continent, lately have begun to import English Fords, Vauxhalls and Opels for sale in this country. In so doing they are paying belated tribute not to styling or performance, but to such workaday virtues as efficiency and economy. Whatever its defects or lacks, the small car is a reliable and sturdy conveyance. It is, moreover, considerably cheaper than the standard American make, both to buy and to operate. Plainly, on a growing number of motorists, whether happy or otherwise, cost and upkeep have exercised their own powerful brand of persuasion. Thus, after a long psychic joy-ride, the public again is getting its feet on the ground. Here is a turn of events with great significance, not merely for Detroit, but also for the rest of the American industry. During the recent inflated prosperity, the mechanism of price and value somehow got out of kilter. Now, as the triumph of the small car suggests, it is being restored to working order. The change may be painful, temporarily at least, for some. In the long run, however, it is bound to be good for everyone.

Modification of Basis for Radiation Dose Calibrations

IN a joint statement, the National Bureau of Standards in Washington, D.C., and the National Research Council of Canada have announced a change, which took effect January 1, 1958, in the basis for instrument calibrations in röntgens in the energy region from 0·5 to 3MeV. The change is due to a revised estimate, based on improved data, of the "stopping power" corrections that must be applied to the materials involved in the calibration. Affecting instruments that measure radiation exposure dose, the new calibration base results in a small change in the calibration factor for radiation in the indicated higher energy range. Thus, to conform to the new basis, instruments calibrated in röntgens with cobalt-60 gamma-rays prior to January 1, 1958, should have their calibration factors reduced by 1·8 per cent, and those whose scales were calibrated prior to that date should have their scale readings changed in the same way, i.e. multiplied by 0·982.

Radiation exposure dose is a measure of the radiation incident at a point in terms of its ability to produce ions in air. For radiation energies below 0·5 MeV, a relatively direct measurement of the amount of such ionisation can be made with the free-air ionisation chamber. At higher

energies, however, the size of the chamber required becomes impracticably large, even when the air density is increased by maintaining a high pressure. Hence, at higher energies a different instrument is used, consisting of a small air cavity surrounded by a wall of solid material several millimetres thick. The ionisation produced within such a cavity is caused mainly by electrons that the radiation ejects from atoms in the wall. As a result, in calibrating such a device, the most important parameter is the ratio of the stopping power of the wall material to that of air. Alternatively, cavity instruments are sometimes calibrated with the radiation from a known weight of radium in a platinum capsule, and this requires a knowledge of the exposure dose rate at 1cm from such a source. However, this rate has been determined from cavity chamber measurements. Thus, all measurements of exposure dose in the 0·5 to 3MeV region depend on values for the stopping power. As indicated in the joint statement that follows, recent experimental studies of stopping power gave results that disagree somewhat with the values calculated by the method hitherto in use. The revised calibration base was adopted after careful analysis of these laboratory studies, which were carried out by the National Research Council of Canada, the National Bureau of Standards and others.

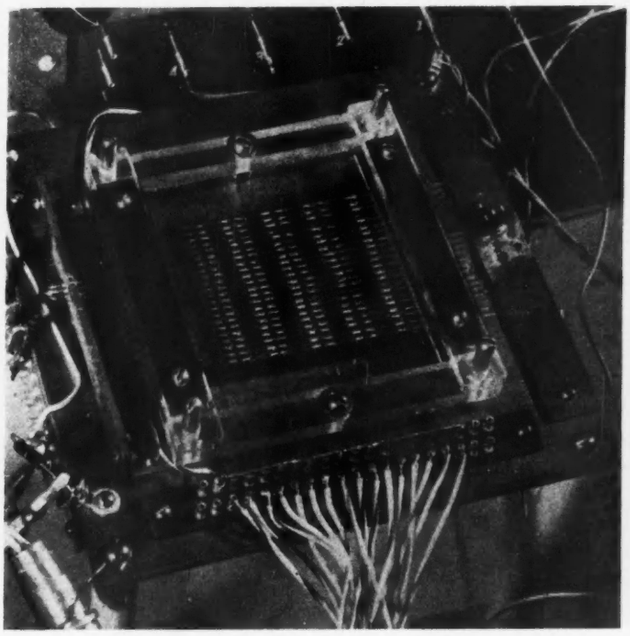
"As a result of recently accumulated information the National Bureau of Standards and the National Research Council of Canada have decided to change the base for instrument calibrations in röntgens in the energy region from 0·5 to 3MeV. This note announces the date the change will become effective and the reasons for it. Only a few measurements with free-air chambers have been attempted in the megavolt region, and there seems to be some doubt as to the adequacy of all of these measurements. Most röntgen measurements in this region are actually made with cavity ionisation chambers. Their sensitivity is determined either from the Bragg-Gray relation with a stopping power correction, or from the calibration of a chamber with radium together with a value for the number of röntgens per hour at 1cm from 1 mg of radium encapsulated in 0·5mm of platinum. Because the value of this constant k is determined from cavity chamber measurements, it is evident that all measurements in röntgens in the megavolt region depend upon a stopping power correction at the present time.

"Until now the stopping power corrections used by the National Bureau of Standards and the National Research Council have depended on the analysis of Laurence, which was based on a theoretical assumption of the dependence of stopping power on atomic number. When this analysis was applied to the experimental determinations of k, the mean value obtained was close to 8·4 röntgens per hour at 1cm from 1mg of radium encapsulated in 0·5mm of platinum. This value has been widely used. However, subsequent measurements of stopping powers by Bakker and Segré give a somewhat different dependence on atomic number. Furthermore, independent measurements recently made at the National Research Council and the National Bureau of Standards of the ionisation produced within cavity chambers having different wall materials are more nearly consistent with the values of Bakker and Segré than with those used by Laurence. Attix and Ritz have made a careful redetermination of k; using stopping power corrections based on the values of Bakker and Segré, a stopping power for air based upon a mean excitation potential of 80·5eV, and including a correction for the difference in the "density effect" between the cavity wall and the gas based on the calculations of Sternheimer; their value is $k=8{\cdot}26\pm0{\cdot}05$. Henry has recently obtained the value $8{\cdot}24\pm0{\cdot}08$. Finally, a re-evaluation by Whyte of a number of measurements appearing in the literature gives a mean value of 8·22.

"The evidence indicates the desirability of modifying the calibration basis for megavolt radiation. Therefore, after January 1, 1958, calibrations in the energy region from 0·5 to 3MeV at the National Bureau of Standards and the National Research Council will be based on the Bakker and Segré stopping power values, an average excitation potential of 80·5eV for air, and the Sternheimer density correction. The value $k=8{\cdot}25$ röntgens per hour at 1cm from 1 mg of radium encapsulated in 0·5mm of platinum will be used instead of 8·4. For all instruments that were calibrated in röntgens with cobalt-60 gamma-rays prior to this date, the calibration factor should be reduced by 1·8 per cent in order to agree with the new value (i.e. the calibration factor should be multiplied by 0·982)."

New Magnetic Memory Concept

A NEW concept in memory devices has been developed at the Bell Telephone Laboratories, of Murray Hill, New Jersey. The concept has been named the "Twistor" and is expected to make possible memory systems which are simpler to fabricate and more economical to manufacture than existing systems. Such devices may have extensive applications in computers and electronic switching systems where rapid-access, high-capacity memories are necessary. The "Twistor" concept opens the way for the construction of magnetic memory arrays by merely interweaving horizontal copper wires and vertical magnetic wires much as window screen is woven. Such a device would be similar in appearance to a ferrite core array, but without the cores, and would operate in much the same manner as a core array.



Experimental magnetic memory array with small solenoids wound around glass tubes set up to test the "Twistor" magnetic wire concept

The new concept gets its name "Twistor" from a characteristic of wire made of magnetic material. Torsion applied to such a wire shifts the preferred direction of magnetisation from a longitudinal to a helical path. The coincidence of a circular and a longitudinal magnetic field can then be used to insert information into this wire in the form of a polarised helical magnetisation, and the magnetic wire itself can be used as a sensing means. The application of torsion to the magnetic wire in a final device may be unnecessary, as the helical path for the preferred direction of magnetisation can perhaps be "frozen" into the wire during processing. In practice, the circular magnetic field is provided by a current pulse through the magnetic wire, and the longitudinal field by a current pulse through the copper wire which is perpendicular to the magnetic wire. Thus, storing a "bit" requires two coincident current pulses. One pulse by itself is insufficient to store a bit. Read-out is accomplished by over-driving the longitudinal field in the reverse direction. The read-out signal is sensed across the magnetic wire. Because the lines of magnetic flux along the helical path wrap the magnetic conductor many times, a favourable increase in the output signal is obtained.

Investigations are now under way to determine the optimum size and composition for the magnetic wires. It appears that a conductor plated with magnetic material may have some advantages. Diameters as small as one-thousandth of an inch appear to be feasible. At least ten bits per inch may be stored on such a wire without adverse interaction. In conventional magnetic core memory devices, conductors must be threaded through the cores to make up a suitable matrix. When a ferrite sheet is employed, either a threading or a plating operation is necessary to place the conductors suitably. However, with the "Twistor," the ferrite material is completely eliminated and no threading or plating is necessary. The speed of operation and output of the "Twistor" are comparable to those of ferrite memory systems. Present indications are that the drive circuits for a "Twistor" array can be readily "transistorised." Thus, a memory system using the "Twistor" concept will retain all of the advantages of ferrite core or sheet systems and will be much simpler and more economical to make.

U.S.-German Nuclear Energy Firm

INTERATOM, the first jointly owned international company in the German nuclear energy field, has been formed by Demag A.G. of Duisburg, and North American Aviation, Incorporated, Atomics International Division. INTERATOM, which stands for Internationale Atomreaktorbau G.m.b.H., will be engaged in developing the peaceful uses of atomic energy, including the design and manufacturing of nuclear reactors and related products. Initial operations of the company will be to promote the sale of nuclear reactors for the production of power and for scientific research. During the period of organisation of the new company, the major responsibility for engineering and manufacturing of nuclear products will rest with Atomics International in America and INTERATOM will be chiefly concerned with overall project management and sub-contracting activities in Germany.

Demag A.G. is engaged in the design and manufacture of heavy machinery and equipment and in the design and installation of chemical, steel and similar plants. The Atomics International Division, with headquarters at Canoga Park, near Los Angeles, California, is one of the major firms engaged in the atomic energy industry in the United States. The division has built and is operating two nuclear power reactors which are part of the U.S. Atomic Energy Commission's programme to develop economical power from atomic energy. Atomics International designed and built research reactors now operating in Denmark and Japan, with two more expected to begin operations shortly in West Berlin and West Germany, and another one under construction for Italy. Four more research reactors built by the division are in operation in the United States.

Personal and Business

Appointments

MR. A. A. KAY has been appointed assistant chief engineer of the radio and television division of the Plessey Company, Ltd.

MR. N. G. WORSTER, A.M.I.E.E., A.M.I.Mech.E., has been appointed chief development engineer of Measuring Instruments (Pullin), Ltd.

MR. L. H. COOPER, vice-president of the International Nickel Company of Canada, Ltd., has been elected a director of that company.

MR. A. C. YEATES, M.I.Mech.E., has been appointed chairman of Crossley Premier Engines, Ltd., in succession to the late Sir Kenneth I. Crossley, Bt.

MARTONAIR, Ltd., has announced the appointment of a further technical representative in the north-west. Mr. S. Teasdale has been accredited to south Manchester and an area enclosed by Chester, Crewe, and Oldham.

THE BRITISH TRANSPORT COMMISSION has announced the following appointments :—Mr. P. Corbishley has been appointed senior instructor, work study training centre, Watford. Mr. E. J. Card has been appointed a supplies officer.

THE MINISTRY OF SUPPLY has announced the appointment of Mr. S. E. Van Ryssen as director of ordnance factories (ammunition) in succession to Mr. L. S. Flatman who has retired. Mr. D. H. Mizen has succeeded Mr. Van Ryssen as senior superintendent of the Royal Ordnance Factory, Woolwich.

MR. J. HENDERSON has been appointed chief engineer superintendent (fleet maintenance) and Mr. E. H. W. Platt, chief engineer superintendent (new construction) of BP Tanker Company. These appointments follow the retirement of Mr. J. W. S. Straughan from the position of chief engineer superintendent, after nearly forty-one years' service with the company.

MR. WILLIAM IRVIN has been appointed information officer to the shipbuilding industry. He will take up his duties on March 3 at 21, Grosvenor Place, London, S.W.1 (telephone, Sloane 9937). The announcement about this appointment is made jointly by the Shipbuilding Conference, the Ship-building Employers Federation, the Dry Dock Owners and Repairers Central Council and the National Association of Marine Enginebuilders.

GEORGE KENT, Ltd., Luton, states that Mr. L. A. C. Bartlett, A.M.I.Mech.E., now takes responsibility for the overall supervision of the steering gear division. Mr. R. S. Medlock, A.M.I.Mech.E., has become the company's technical and home sales director, Mr. E. E. Cook has been appointed director of the company's central sales organisation in Australia, and Mr. J. Tham succeeds Mr. Cook as home sales manager. Mr. K. Scanes becomes responsible for relations with overseas subsidiary companies and Mr. W. G. Askew is taking charge of the company's exhibitions departments. Mr. W. T. H. Carter has been appointed chief buyer for the instrument division.

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY has announced the following appointments:—Mr. J. C. C. Stewart, formerly director of technical policy in the industrial group at Risley, becomes a deputy managing director of the industrial group; Mr. J. B. W. Cunningham, formerly deputy director (civil reactors), becomes director of industrial power in the industrial group ; Dr. R. Hurst, formerly chief chemist in the research and development branch of the industrial group at Risley, becomes director of the Dounreay experimental reactor establishment, and Mr. D. S. Mitchell, formerly director of administration, becomes director of personnel and administration in the industrial group. Mr. D. W. Fry, chief physicist at Harwell, has been appointed a deputy director of the Atomic Energy Research Establishment.

Business Announcements

SIR BRUCE WHITE, WOLFE BARRY AND PARTNERS, 1, Lygon Place, London, S.W.1, state that their telephone number has been changed to Sloane 3433.

THE FAIREY AVIATION COMPANY, Ltd., has announced that Mr. L. Massey Hilton, A.F.R.Ae.S., acting on medical advice, has retired from the board of directors.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that an additional exchange line has been connected at its Aberdeen branch office and the new telephone numbers are Aberdeen 53351-2.

CAWKELL RESEARCH AND ELECTRONICS, Ltd., 6-8, Victory Arcade, Broadway, Southall, Middlesex, has been formed to extend the activities of the former A. E. Cawkell, electronic engineers. The directors are Mr. A. E. Cawkell (managing) and Mr. J. Rotheroe.

BRITISH INSULATED CALLENDER'S CONSTRUCTION COMPANY, Ltd., states that the address of its Glasgow office is now 110A, Maxwell Avenue, Westerton, Bearsden, Glasgow (telephone Bearsden 2382-3).

W. E. SYKES, Ltd., Staines, has opened offices at Grove House, Sutton New Road, Erdington, Birmingham 24 (telephone, Erdington 7491). The company's Midlands representative, Mr. P. Franks, now operates from that address.

DAVY AND UNITED ENGINEERING COMPANY, Ltd., and Booker Brothers, McConnell and Co., Ltd., state that Bookers Engineering Holdings, Ltd., has purchased Duncan Stewart and Co., Ltd., Glasgow, the sugar machinery company of the Davy-United group.

THE GAMLEN CHEMICAL COMPANY announces that it is extending its marketing activities in Southern Africa, and that it is forming a subsidiary company there under the management of Mr. J. A. Vorster. Mr. Vorster will leave on March 6, to take up residence in Durban.

THE PULSOMETER ENGINEERING COMPANY, Ltd., states that its associate, the Self-Priming Pump and Engineering Company, Ltd., Slough, is to be known in future as S.P.E. Company, Ltd. The London office of this company is now at 20-26, Lamb's Conduit Street, W.C.1.

BRITISH CONSOLIDATED FOUNDRY PLANT MANUFACTURERS is the title of an export consortium formed to co-ordinate the exports of the following foundry plant and machinery manufacturers :—Acme Conveyors, Ltd., Coleman-Wallwork, Ltd., Metalectric Furnaces, Ltd., Paterson Hughes Engineering Company, Ltd., and Tilghman's, Ltd.

WARNE, WRIGHT AND ROWLAND, Ltd., states that it has merged the manufacturing activities of its subsidiaries W. T. French and Son, Ltd., G. and W. Purser, Ltd., Carpenter and Allen, Ltd., and Ladbrook Stampings, Ltd., into one company known as Browning Street Industries, Ltd., in its factory at Browning Street, Ladywood, Birmingham, 16.

WILTON AND BELL, chartered civil engineers, state that they have taken into partnership Mr. J. A. Williams, M.I.C.E., M.I.Struct.E., a senior member of their staff. The office address of Wilton and Bell has been changed from 25, Victoria Street, London, S.W.1, to Roman House, Cripplegate Buildings, London Wall, London, E.C.2 (telephone Monarch 6341-2).

Miscellanea

MR. JOSEPH STENNER.—We regret to note the death of Mr. Joseph Stenner, which occurred at Tiverton, on February 5. Mr. Stenner, who was eighty-two, had been associated with Stenners of Tiverton, Ltd., for sixty-seven years, having served it as a director until 1949.

SIR ALEXANDER GIBB.—On page 209 of last week's issue, there was printed an "Appreciation" of Sir Alexander Gibb. It was signed George Maunsell ; but should have been signed Guy Maunsell. Our apologies are due to Mr. Maunsell. The error was wholly of our making.

WORKS EXTENSION IN NORTHERN IRELAND.—It is announced that an extension nearing completion at the Castlereagh, Belfast, works of the British Tabulating Machine Company, Ltd., which will add 100,000 square feet to the production area, is to be increased by a second 100,000 square feet extension. When the two extensions are completed the present staff of 1500 will be increased to 2500. A description of this factory at Castlereagh was published in our issue of April 11, 1952, and it will eventually be the largest of the firm's nine factories in Britain.

INDUSTRIAL EDUCATION.—The twelfth annual residential summer school of the Institute of the Motor Industry will be held at St. Catharine's College, Cambridge, from August 23 to 30, 1958. The programme, which is determined by those who enrol before the end of February, is likely to cover important management, administrative, sales promotion, distributive and legal subjects with particular application to the motor industry. Applications should be made to the Institute of the Motor Industry (Inc.), 40, Queen's Gate, London, S.W.7.

CONFERENCE ON FUEL RESEARCH.—A report has now been published on the second Specialist Conference on Fuel Research which was held in London from July 9 to 16, 1956. The conference was attended by delegates from official research organisations in the United Kingdom, Canada, Australia, New Zealand, South Africa, India, Rhodesia and Nyasaland and the Colonies. It was held under the chairmanship of Dr. A. Parker, C.B.E., Director of Fuel Research, and the conference discussed existing facilities for training in fuel technology and for carrying out fuel research in the Commonwealth, and the possibility of improving and augmenting these facilities. The possibilities of collaboration between the Commonwealth organisations in investigational work were discussed and arrangements made to initiate joint investigations in the fields of coke testing, coal grindability and petrographical work. To ensure the fullest possible exchange of information between Commonwealth organisations interested in fuel research the Conference recommended that state-aided research organisations and nationalised industries actively engaged in fuel research should be invited to participate as full members in future conferences.

ALUMINIUM ALLOY CASTINGS.—A new edition of the handbook *Melting Practice for the Production of Aluminium Alloy Castings* has been issued by Alar, Ltd., 3, Albemarle Street, London, W.1, a technical association of light alloy refiners. This essentially practical book is designed to explain to the man in the foundry the practical considerations in the melting and preparation of aluminium alloys up to the casting stage. The information given is based upon the recommendations of the technical staffs of the members of the association, and the book is issued free of charge to interested foundrymen.

INVENTIONS BY COAL BOARD EMPLOYEES.—Seventeen National Coal Board employees who made technical inventions useful to the mining industry shared awards totalling £3100 in the year ended September 30, 1957. The awards were made, under a scheme introduced early in 1952 as an incentive to workers in the industry to exercise their ingenuity, by the Board's National Awards Tribunal, which has now awarded nearly £44,000 since the scheme began. Awards of up to £100 each can also be made by Divisional Panels ; during the year under review these panels made awards totalling over £3000 to 125 people. Since the scheme began a total of nearly £16,000 has been awarded by Divisional Panels.

GRAPHITE BURSTING DISCS.—A range of bursting disc assemblies in carbon and graphite, is now available from Powell Duffryn Carbon Products of Hayes, Middlesex. The bursting assembly comprises a two-part carbon holder and a high quality replaceable graphite disc which is easy to install and locate. A standard range of discs available covers 2in, 3in, 4in and 6in bores for pressures between 5 lb and 75 lb per square inch gauge. Bursting accuracy of the discs is guaranteed within ± 5 per cent of the rated burst pressure.

LIQUID NATURAL GAS.—A contract has been signed between the Gas Council (Great Britain) and the Constock Liquid Methane Corporation of America for the experimental importation into Great Britain of liquefied natural gas by sea. A cargo ship, jointly owned by the council and the corporation, is being converted to carry about 2000 tons of liquid natural gas, and it is hoped that the first ship load will arrive in the Thames within about twelve months. It was stated recently by Sir Harold Smith that if this experiment proves successful it is hoped that the way will be open, subject to Government sanction, to the importation of liquefied natural gas in bulk.

DIESEL ENGINEERS AND USERS ASSOCIATION.—On Thursday, November 21, G. R. Green read his paper, "Fuel Injection Equipment," before the Diesel Engineers and Users Association. The paper considers the task to be performed by the fuel injection equipment and facts and figures relating to a particular engine are stated. Detail design of the pump is examined and there are notes upon the nozzles for air cell and open chamber, while questions relating to delivery valves are examined. Manufacturing considerations and functional requirements are dealt with, followed by notes upon cooled injectors, dual-fuel engines, variable injection timing and servo-operation. Other sections of the paper are concerned with distributor pumps, unit injectors, special applications, such as the free-piston engine, and governing.

PLASTIC PACKING FOR COOLING TOWERS.—The American associates of Head Wrightson Processes, Ltd., the Fluor Products Company, have designed a new plastics packing for "Counterflo" cooling towers which is known as "Poly-Grid." This packing is stated to produce a greater cooling surface and an increased flow of heat transfer than is possible with the standard timber grid decks at present in common use. The new grid has an open construction and its pressure drop is low, permitting more water to be cooled, or a greater degree of cooling under existing operating conditions. Further research has also resulted in the development of asbestos panels for the construction of cooling tower walls, as an alternative to timber panels, and of off-set louvres which decrease the pressure drop of the air drawn into the tower.

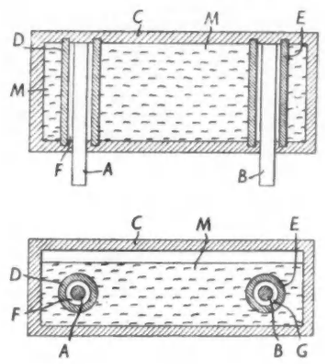
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

FURNACES

782,128. December 17, 1954.—ELECTRIC MELTING FURNACES, Jenaer Glaswerk Schott and Gen., Mainz, Germany.

The invention relates to an electric melting furnace intended for the manufacture and/or working up of glass, the material to be melted or the molten material being at least partly heated by means of electrodes by Joule heat. Referring to the drawing, the electrodes *A* and *B* are introduced laterally



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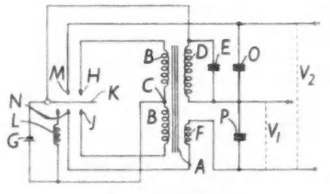
through the walls of the melting chamber *C*. The electrodes are surrounded by tubular diaphragms *D* and *E* and are thereby physically separated from the melt *M* to be worked up. The spaces *F* and *G* into which the electrodes project, contain a material which has a different chemical composition from the melt, particularly a substance with a low oxygen-ion concentration, which limits to a minimum the detrimental action on the electrode material. Such a material could be a glass with a high content of B_2O_3 (boron oxide). The diaphragms *D* and *E* consist of materials which in the region of the melting temperatures employed in the furnace, constitute conductors or semi-conductors for the electric current so that the current is not interrupted by the diaphragm. When desired three or more electrodes can be employed.—*September* 4, 1957.

ELECTRICAL ENGINEERING

787,388. July 22, 1954.—ELECTRIC POWER SYSTEMS INCORPORATING VIBRATORY INTERRUPTORS, The Plessey Company Ltd., 56, Vicarage Lane, Ilford, Essex. (*Inventor: George Henry Wheeler.*)

The invention relates to electric power systems and is particularly applicable to a system utilising electromagnetic vibrators, its object being to provide an improved power supply system for supplying electric energy at two direct voltages from a power supply source, or for balancing the output from the system should two unequal loads be supplied from equal direct voltages. In the drawing, a transformer core *A* carries a primary winding *B* having a centre



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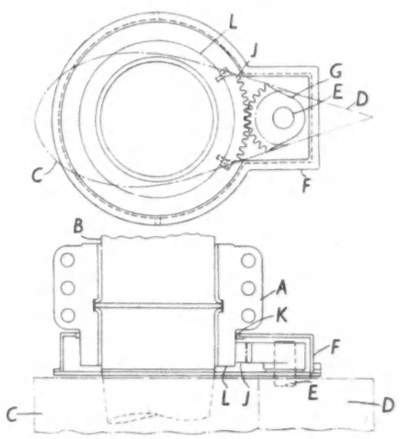
tapping *C*, a main secondary winding *D* which is protected by a condenser *E* of small capacitance, and an auxiliary winding *F*. Current from a battery *G* is supplied alternately to the two halves of the primary winding *B* by means of a contact pair *H* and *J* controlled by the reed *K* of a vibrator *L* so as to produce an alternating flux in the core *A*. A second contact pair *M* and *N* of the vibrator *L* serves to connect (in synchronism with the change-over of the primary) one end of the main secondary winding *D* alternately to two condensers *O* and *P*, each of which has its second terminal permanently connected to the free end of the main secondary winding *D*, the contact *M* being directly connected to its associated condenser *O*, while the auxiliary secondary winding *F* is interposed in series in the connection between the second condenser *P* and its associated vibrator contact *N*. During one half-period of each transformer cycle the condenser *O* will be charged by the voltage produced between the terminals of the main secondary winding *D*; when, during the next half-period, the voltage produced in winding *D* changes its sign, the circuit employed for charging condenser *O* will be open at contact *M* while during the later half-period condenser *P* will be charged by the algebraic sum of the voltage produced in winding *D* and that produced in the auxiliary secondary winding *F*. Assuming first the latter voltage to be zero, thus reducing the circuit to the conventional voltage doubler, a voltage V_2 will therefore be available between the outer terminals of the condensers *O* and *P* which is equal to twice the voltage V_1 to which condenser *P* is charged. In the arrangement according to the invention, however, the voltage produced in the auxiliary winding *F* is added to or subtracted from the voltage produced in the main secondary winding *D* for charging the condenser *P* so that the voltage V_2 will differ from the voltage across condenser *O*. By suitably choosing the number of turns in windings *D* and *F* the two output voltages V_1 and V_2 may each be chosen independently of the other. On the other hand the invention can also be usefully employed when the voltages across condensers *O* and *P* are required to be used as two equal voltages of opposite polarities subjected to different loads. In this case the auxiliary winding *F* when suitably dimensioned will serve as a voltage boost compensating for the difference in loading.—*December* 4, 1957.

MARINE ENGINEERING

789,253. October 12, 1955.—ANTI-ROLLING APPARATUS FOR SHIPS, Brown Brothers and Co., Ltd., Rosebank Iron Works, Edinburgh, Scotland, William Denny and Brothers Ltd., Leven Ship Yard, Dumbarton, Scotland, and James Alexander Walker Sinclair, 22, McDonald Place, Edinburgh, Scotland.

An anti-rolling device according to the invention includes fins each carrying a tail flap pivoted to it, and means incorporating an epicyclic gear train for causing swinging movement of the tail flap consequent on swinging movement of the fin. In the drawing *A* is a bearing supporting a fin shaft *B*, and *C* drawn in chain dotted lines is a fin attached to the shaft, the fin carrying a tail flap *D* fastened to a flap shaft *E* supported by the fin and extending in an inboard direction into a watertight gear case *F*. The inner end portion of the flap shaft carries a sector *G* with



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peripheral teeth which mesh with corresponding teeth on a segment *J* fixed to the bearing within the gear case *F*. *K* is a sealing ring for preventing ingress of water to the gear case, the sealing ring bearing against the outer surface of a tubular portion *L* of the bearing. In practice, the sector *G* functions as a portion of a planet wheel and the segment *J* functions as a portion of a sun wheel, the sector and the segment constituting an epicyclic gear. When the fin *C* is swung through a particular angle carrying with it the tail flap *D*, the flap shaft *E* is carried with it. Since the sector *G* is fastened to the flap shaft and meshes with the fixed segment *J* it is subjected to translation and rotation, and the tail flap, fixed to it, is also subjected to translation and rotation resulting in a swinging movement of the flap greater than the swinging movement of the fin. The ratio of the angle through which the tail flap swings to the angle through which the fin swings is always the same whatever the angle through which the fin swings. A mechanism according to the invention is compact and can easily be accommodated without encroaching on the space necessary for the fin shaft bearing.—*January* 15, 1958.

METALLURGY

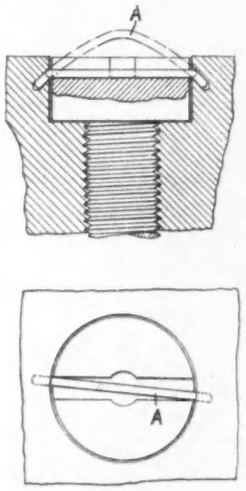
788,236. May 13, 1955.—STEEL PARTS SUBJECTED TO ROLLING FRICTION, Max Fink, Mufferter Weg 25, Aachen, Germany.

The invention relates to steel parts subjected to rolling friction—for example, rails, wheel tyres and roller bearings. According to the invention there is provided a part subjected to rolling friction—for example, a rail, a wheel tyre, or a roller bearing, wherein the parts are made of a steel having a nitrogen content of 0·005 per cent by weight or less. This causes oxide films to be produced on and adhere very quickly to the surface of the part. The films are capable of withstanding tangential forces, and are not destroyed by vehicles rolling over the rails or by other objects stressing them. Firmly adhering film-like coatings of this kind also protect the steel layer under the film against attack by oxygen and nitrogen. Of course, rail and other running surfaces of this kind do wear out, but the formation of new films from the metal surface always continues in good time, and because of these properties of the oxide films the rails or other running surfaces are so resistant that wear dust cannot form or accumulate, nor can corrugating occur. With steel of this kind, oxide films are formed which are sufficiently resistant to the rubbing oscillations. If the oxygen content of the steel is kept particularly low so as to be in the vicinity of 0·01 per cent by weight, or less, an adequate surety is given that in such steel, corrugating will be prevented to a considerable extent, for a low oxygen content is important for the formation of firmly adhering oxide films.—*December* 23, 1957.

SCREW LOCKING DEVICES

788,871. July 18, 1955.—THE LOCKING OF SCREWS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor: Frank Cowham.*)

The invention relates to the locking of screws in position against vibration, and is eminently but not exclusively applicable to large diameter screws, such as 1¼in Whitworth screws employed in dynamo-electric machines. In the drawing there is shown a screw locked in position by means of a locking pin *A* which extends across an enlarged end or counterbore accommodating the screw head. The pin is disposed in the slot in the head, its ends being received in holes in the counterbore. The mouths



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of the holes are in alignment or substantially in alignment with the corresponding ends of the slot. In order to lock the screw the pin is inserted in a pre-bent form as shown in chain-dotted line, into the counterbore so that its ends locate in the outer ends of the screw slot and in the mouths of the holes. By hammering or otherwise the locking pin is then flattened as shown, in full line, its ends being driven into the adjacent holes. If only one hole is provided the other end of the locking pin will be driven into tight engagement with the adjacent surface of the wall of the counterbore. The pin may be removed from the slot by prising it away from the screw head by a screwdriver inserted in the slot and in a hole preferably provided for that purpose.—*January* 8, 1958.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ANTIQUARIAN HOROLOGICAL SOCIETY

To-day, Feb. 14.—Lecture Theatre, Science Museum, Kensington, S.W.7, "Clock Escapements," W. J. Gazeley, 7 p.m.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Sat., Feb. 15.—OXFORD, READING AND DISTRICTS BRANCH: Collier Lecture Room, Regent's Park College, Pusey Street, Oxford, "Lighting Specification, Design and Planning," 7 p.m.
Tues., Feb. 18.—TYNESIDE BRANCH: Crown Hotel, Clayton Street West, Newcastle, "Turbine Supervisory Equipment," E. D. Kelly, 7.30 p.m.
Thurs., Feb. 20.—KENT BRANCH: Royal Clarendon Hotel, Gravesend, Film Show, 7.30 p.m. ★ NORTH WEST LONDON BRANCH: Afternoon Visit to Cadby Hall.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Feb. 19.—MERSEYSIDE SECTION: Technical College, Birkenhead, "Closed-Circuit Television," J. G. M. Downes, 7 p.m.
Thurs., Feb. 20.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, "Frequency Response Instrumentation for the Analysis, Design and Production of Servomechanisms," G. R. Swainston, 7 p.m.
Fri., Feb. 21.—SCOTTISH SECTION: Department of Natural Philosophy, The University, Edinburgh, "Frequency Response Instrumentation for the Analysis, Design and Production of Servomechanisms," G. R. Swainston, 7 p.m.

DIESEL ENGINEERS AND USERS ASSOCIATION

Thurs., Feb. 20.—Caxton Hall, Westminster, London, S.W.1, "Engine Evolution: Non-Marine Engines Over a Quarter of a Century," D. S. D. Williams, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Thurs., Feb. 20.—MANCHESTER CENTRE: Demonstration Theatre, N.W. Electricity Board, Town Hall, Manchester, 2, "Lighting at London Airport," J. G. Holmes, 6 p.m.
Mon., Feb. 24.—LEEDS CENTRE: Lighting Service Bureau, 24, Aire Street, Leeds, 1, "Photo-Electric Cells and their Applications," F. A. Benson, 6.15 p.m. ★ LEICESTER CENTRE: Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, "Street Lighting Forum," G. Mainwaring," 7 p.m.
Tues., Feb. 25.—LEEDS CENTRE: Yorkshire Electricity Board, Forensway, Hull, "Photo-Electric Cells and their Applications," F. A. Benson, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Wed., Feb. 19.—BIRMINGHAM BRANCH: Hotel Leofric, Coventry, "Slinging and Handling," A. Thwaite, 7.30 p.m. ★ KENT BRANCH: King's Head Hotel, High Street, Rochester, "Applications of Photography in Science and Engineering," J. F. Padday, 7 p.m.
Thurs., Feb. 20.—BLACKBURN BRANCH: Golden Lion Hotel, Blackburn, "Nuclear Reactors for Power Production," J. A. Dixon, 7.30 p.m.
Mon., Feb. 24.—WEST AND EAST YORKSHIRE BRANCH: The University, Leeds, "A Liberal Education in a Scientific World," 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Feb. 18.—EAST ANGLIAN SECTION: Lecture Hall, Public Library, Ipswich, "Mechanization of a Small Jobbing Foundry," R. Blandy, 7.30 p.m.

INSTITUTE OF FUEL

Wed., Feb. 19.—Institution of Civil Engineers, Great George Street, London, S.W.1, Melchett Lecture, "Nuclear Power Development: Some Experiences of the First Ten Years," Sir Christopher Hinton, 5.30 p.m.
Thurs., Feb. 20.—N.W. SECTION: Blossoms Hotel, Chester, "Coal and Oil as Partners in Energy Supply," R. R. Gordon, 7.30 p.m. ★ MERSEY SECTION: Liverpool Engineering Society's Rooms, 9, The Temple, Dale Street, Liverpool, "Heating, Ventilating and Air Conditioning," C. G. Bell, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Feb. 17.—SOUTHERN JOINT BRANCH: Portsmouth College of Technology, Portsmouth, with the Institution of Naval Architects, "Nuclear Power for Ship Propulsion," S. L. Smith, 7.30 p.m.
Mon., Feb. 24.—WEST OF ENGLAND SECTION: Grand Hotel, Bristol, Annual General Meeting, Film Show, 7.30 p.m.

INSTITUTE OF METALS

Thurs., Feb. 20.—BIRMINGHAM LOCAL SECTION: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Neutron Irradiation Effects in Metals," J. G. Ball, 6.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, Feb. 14.—SOUTH WALES CENTRE: South Wales Institute of Engineers, Park Place, Cardiff, "Various Trends in Machining and Inspection Methods Concerning the Manufacture of Heavy Commercial Vehicles," R. P. Chilton, 7 p.m. ★ WESTERN CENTRE: Rougement Hotel, Exeter, "Gas Turbines and their Application to Road Transport," A. Enticknap, 7 p.m.
Mon., Feb. 17.—SCOTTISH CENTRE: North British Hotel, Edinburgh, "The Adaption of Commercial Vehicles for Use in a Special Purpose Mixed Fleet," R. H. R. Hacker, 7.30 p.m.
Tues., Feb. 18.—NORTH EASTERN CENTRE: Three Tuns Hotel, Durham City, "Some Considerations Affecting the Selection and Use of Fuels and Lubricants for Road Transport," C. G. Tresidder, 7 p.m.
Thurs., Feb. 20.—METROPOLITAN AREA: Royal Society of Arts, John Adam Street, London, W.C.2, "The Free Piston Gasifyer with Special Reference to Vehicle Applications," B. C. Lovatt, 6.30 p.m. ★ YORKSHIRE CENTRE: Great Northern Hotel, Wellington Street, Leeds, 1, "Air Brakes and Auxiliaries for Commercial Vehicles," W. A. Kirk, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Feb. 18.—MANCHESTER GRADUATES' AND STUDENTS' CENTRE AND NORTH WESTERN BRANCH: Reynolds Hall, College of Science and Technology, Manchester, Symposium on Tools of Chemical Production Management, 3 p.m.
Wed., Feb. 19.—MIDLANDS GRADUATES' AND STUDENTS' CENTRE: Chemical Engineering Lecture Theatre, The University, Edgbaston, Birmingham, "The Instrumentation of Modern Chemical Plant," A. H. Isaacs, 6.30 p.m.
Thurs., Feb. 20.—YORKSHIRE GRADUATES' AND STUDENTS' CENTRE: Fuel Dept., The University, Leeds, Annual Centre Meeting, Films, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 18.—Great George Street, Westminster, London, S.W.1, "Jodrell Bank Radio Telescope," H. C. Husband, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Feb. 14.—NORTH EASTERN GRADUATE AND STUDENT SECTION: Grey Hall, King's College, Newcastle upon Tyne, "Nuclear Power Stations," A. St. John MacKellar, 6.30 p.m. ★ NORTH SCOTLAND SUB-CENTRE: Robert Gordon's Technical College, Aberdeen, "Some Recent Developments in Power Transformer Manufacture," A. C. Franklin, 7.30 p.m.
Mon., Feb. 17.—MERSEY AND N. WALES CENTRE: Royal Institution, Colquitt Street, Liverpool, Discussion on the Report "The Supply and Training of Teachers for Technical Colleges," introduced by Willis Jackson, 6.30 p.m. ★ NORTH EASTERN RADIO AND MEASUREMENTS GROUP: King's College, Newcastle upon Tyne, "The Measurement of High Voltages with Indicating or Recording Instruments," G. W. Bowdler, 6.15 p.m. ★ WESTERN SUPPLY GROUP: The University, Large Lecture Theatre, Engineering Department, University Walk, Bristol, "Mechanical Strength of Power Transformers in Service," E. T. Norris, 6 p.m.
Tues., Feb. 18.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, "Magnetic Tape for Data Recording," C. D. Mee, to be read by J. F. Doust, 5.30 p.m. ★ EAST ANGLIAN SUB-CENTRE: Technical College, Collier Road, Cambridge, "275kV Transmission Lines," J. D. Pierce, 6 p.m. ★ NORTH EASTERN CENTRE: Workington College of Further Education, Workington, "Germanium and Silicon Power Rectifiers," T. H. Kinman, G. A. Garrick, R. G. Hibberd and A. J. Blundell, 7 p.m. ★ NORTH MIDLAND UTILIZATION GROUP: C.E.A. Yorkshire Division, 1, Whitehall Road, Leeds, 1, "Development of Transportable Thermal-Storage Space Heaters," E. Bates, 6.30 p.m. ★ NORTH WESTERN MEASUREMENT AND CONTROL GROUP: Engineers' Club, 17, Albert Square, Manchester, "The Breakdown of Transformer Oil under Impulse Voltages," R. Hancox, 6.15 p.m. ★ SOUTH EAST SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "British Columbia–Vancouver Island 138kV Submarine Power Cable," T. Ingledow, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson, 7 p.m. ★ NORTH STAFFORDSHIRE SUB-CENTRE: Victoria Hall, Hanley, "The Electrification of the British Railways," by the late G. H. Fletcher, to be read by R. Ledger, 7.30 p.m. ★ WESTERN SUPPLY GROUP: Electricity Showrooms, New George Street, Plymouth, Joint Meeting with South Western Sub-Centre, "Mechanical Strength of Power Transformers in Service," E. T. Norris, 3 p.m.
Wed., Feb. 19.—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, "The Relation Between Picture Size, Viewing Distance and Picture Quality with Special Reference to Colour Television and to Spot-Wobble Techniques," L. C. Jesty, 5.30 p.m. ★ SHEFFIELD SUB-CENTRE: Grand Hotel, Sheffield, "Supply-Voltage and Current Variations Produced by a 60-ton, Three-phase Arc Furnace," B. C. Robinson and A. I. Winder, 6.30 p.m.
Thurs., Feb. 20.—EAST MIDLAND CENTRE: Albert Hall, Nottingham, "The Electrification of the British Railways," by the late G. H. Fletcher, to be read by R. Ledger, 7.15 p.m.
Fri., Feb. 21.—NORTH EASTERN CENTRE: Technical College, Carlisle, "Earthing of Low and Medium-Voltage Distribution Systems and Equipment," F. Mather, 7 p.m.
Mon., Feb. 24.—NORTH EASTERN CENTRE: Neville Hall, Newcastle upon Tyne, "Design and Application of Large Solid-Rotor Asynchronous Generators," P. Richardson, 6.15 p.m. ★ SOUTH MIDLAND RADIO AND MEASUREMENTS GROUP: James Watt Memorial Institute, Great Charles Street, Birmingham, "Radio Research and the International Geophysical Year," R. L. Smith-Rose, 6 p.m. ★ WESTERN UTILIZATION GROUP: South Wales Institute of Engineers, Cardiff, "Temperature Rises in Electrical Machines on Variable Load and with Variable Speed," A. Tustin and J. J. Bates, 6 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Sat., Feb. 22.—Visit to the Odeon Theatre, Newcastle upon Tyne, 10 a.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 14.—GENERAL MEETING, APPLIED MECHANICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "The Application of Servo-Mechanism Analysis to Fuel Control Problems," O. N. Lawrence and R. D. Powell, 6 p.m. ★ N.E. GRADUATES' SECTION: Grey Hall, King's College, Newcastle upon Tyne, "Nuclear Power Stations," A. St. John MacKellar, 6.30 p.m.
Tues., Feb. 18.—AUTOMOBILE DIVISION: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "The Extent to which Standardisation Should be Pursued in the Motor Industry," 6 p.m. ★ S. WALES BRANCH: Electricity Board's Showrooms, The Kingsway, Swansea, "Principles and Applications of Spark Machining," D. W. Rudorff, 6 p.m.
Wed., Feb. 19.—E. MIDLANDS BRANCH: Bell Hotel, Leicester, "The Influence of Dynamics in High-Speed Machinery," S. A. Makovski, 7.15 p.m. ★ SOUTHERN BRANCH: Sun Hotel, Chatham, "Machinery for Cross-Channel Passenger Ships," E. L. Denny, 7.30 p.m. ★ YORKSHIRE BRANCH: Royal Station Hotel, Hull, "Machinery for Cross-Channel Passenger Ships," E. L. Denny, 7.30 p.m. ★ COVENTRY GRADUATES' SECTION: Wine Lodge, The Burges, Coventry, "Epicyclic Gearboxes," R. E. Moore, 7.30 p.m. ★ WESTERN GRADUATES' SECTION: Engineering Laboratories, The University, Bristol, "Some Problems of Nuclear Power Plant," B. L. Goodlet, 7.15 p.m.
Thurs., Feb. 20.—N.E. BRANCH: Stephenson Building, Claremont Road, Newcastle upon Tyne, "Examination of the Theories of Calculating the Stresses in Pipe Bends Subjected to In-plane Bending," and "Stress and Deflection Studies of Pipe Line Expansion Bellows," C. E. Turner and H. Ford, 6.30 p.m. ★ N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Radioisotopes in Engineering," J. L. Putman, 6.45 p.m. ★ SOUTHERN BRANCH: The University, Southampton, "Marchwood Generating Station: Some Design Considerations and Construction Problems," B. C. Pyle, 6 p.m. ★ E. MIDLAND GRADUATES' SECTION: College of Art, Green Lane, Derby, "Some Aspects of Racing Car Developments," W. R. Flockhart, 7.15 p.m. ★ LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, "History of Mechanical Engineering up to 1840," G. Porges, 6.30 p.m. ★ YORKSHIRE GRADUATES' SECTION: Hotel Metropole, Leeds, "Precision Finishing Machines and Operations," E. D. Haigh, 6.30 p.m.
Fri., Feb. 21.—ORDINARY MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, "Packed Glands for High Pressures: An Analysis of Fundamentals," J. L. Thomson; "Glands for the Entry of Electrical Cables into Pressure Vessels Containing or Surrounded by Conducting Liquids," H. H. Grunwald, 6 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Mon., Feb. 17.—SOUTHERN JOINT BRANCH WITH INSTITUTE OF MARINE ENGINEERS: College of Technology, Anglesea Road, Portsmouth, "Nuclear Power for Ships," S. Livingston Smith, 7.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Feb. 18.—INFORMAL MEETING: Conference Room, Fourth Floor, Waterloo Bridge House, London, S.E.1, "Service to the Region—The Work of L.T.R. Power Section," K. M. Trigwell, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Feb. 14.—IPSWICH AND COLCHESTER SECTION: Golden Lion Hotel, Cornhill, Ipswich, "Designing for Production," A. P. Peat, 7.30 p.m. ★ SWANSEA SECTION: Central Library, Alexandra Road, Swansea, "The Importance of Production Engineering," L. E. Bunnett, 7.30 p.m.
Mon., Feb. 17.—SHEFFIELD GRADUATE SECTION: Beaston, Clark and Co., Ltd., Rotherham, "Glass Making," 6.30 p.m. ★ COVENTRY SECTION: Crawen Arms, High Street, Coventry, "Spark Erosion," Herr Ullmann, 7.15 p.m. ★ MANCHESTER SECTION: College of Science and Technology, Sackville Street, Manchester, "Metal Cutting Lubricants and Coolants," D. A. Wight, 7.15 p.m.
Tues., Feb. 18.—PETERBOROUGH SECTION: Conference Room, Peterscourt, Peterborough, "Electric Welding," J. W. Wright, 7.30 p.m. ★ TEES-SIDE SECTION: Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, "Production Control in General Engineering," T. Nancarrow, 7 p.m.
Wed., Feb. 19.—BIRMINGHAM SECTION: College of Technology, Gosta Green, Birmingham, 4, "Trade Union and Management View Point on Modern Production Developments," Sir Ewart Smith and a Trade Union official, 6.15 p.m. ★ WOLVERHAMPTON GRADUATE SECTION: College of Technology, Wulfruna Street, Wolverhampton, "Ferrous Die Casting," H. E. Redshaw, 7.30 p.m. ★ PRESTON SECTION: Harris College of Further Education, Corporation Street, Preston, "Application of Tungsten Carbide Cutting Tools," H. H. Ward and N. Shaw, 7.30 p.m. ★ SOUTHAMPTON SECTION: Town Hall, Christchurch, Hants, "Design and Construction of an Aircraft Carrier for Naval Operation," A. J. Simms, 7.15 p.m.
Thurs., Feb. 20.—LINCOLN SECTION: Ruston Club, Lincoln, "The Computer Control of Machine Tools," M. Monk, 7.30 p.m. ★ N. IRELAND SECTION: Kensington Hotel, Belfast, "Machining Techniques for Non-Ferrous Materials," S. Radcliffe, 7.30 p.m. ★ LONDON SECTION: Royal Empire Society, Northumberland Avenue, Strand, W.C.2, "Research on Modern Metal-Cutting Techniques," J. Cherry, 7 p.m. ★ LUTON GRADUATE SECTION: Red Hart Hotel, Bucklersbury, Hitchin, Herts, Film Show and Ten-Minute Papers, 7.30 p.m. ★ SOUTHAMPTON SECTION: Polygon Hotel, Southampton, "Manufacture of Electric Power Cables," Dr. Arman, 7.15 p.m.
Mon., Feb. 24.—STOKE-ON-TRENT SECTION: Grand Hotel, Hanley, Stoke-on-Trent, "Design for Production," F. E. Butcher, 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Feb. 17.—MERSEYSIDE SECTION: Exchange Hotel, Liverpool, "Recent Advances in Rubber and Plastics Machinery," K. M. Wilson, 7.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Fri., Feb. 21.—MIDLAND COUNTIES BRANCH: Royal Birmingham Society of Artists Galleries, New Street, Birmingham, "Some Recent Building in Northern Europe," G. Winteringham and B. W. Cooper, 6 p.m.
Mon., Feb. 24.—LONDON GRADUATES' AND STUDENTS' SECTION: 11, Upper Belgrave Street, London, S.W.1, Engineers' Forum, L. E. Hunter, M. E. R. Little and D. N. Mitchell, 6.30 p.m.

INSTITUTION OF WORKS MANAGERS

Thurs., Feb. 20.—DONCASTER BRANCH: Earl of Doncaster Hotel, Doncaster, "Packaging," 7.30 p.m.
Mon., Feb. 24.—GLASGOW BRANCH: St. Enoch Hotel, Glasgow, "Training of Foremen," W. B. Bower, 7.30 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Feb. 14.—Engineers' Club, Albert Square, Manchester, "Models in Engineering," J. A. L. Mathieson, 6.45 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Feb. 14.—STUDENT SECTION: Bolbec Hall, Newcastle upon Tyne, "Nuclear Power Stations," A. St. John MacKellar, 6.45 p.m.
Fri., Feb. 21.—Mining Institute, Newcastle upon Tyne, "The History and Development of Hydraulic Transmissions for Marine Propulsion," D. Firth, 6.15 p.m.

PLASTICS INSTITUTE

Tues., Feb. 18.—Wellcome Building, 183–193, Euston Road, London, N.W.1, "Plastics Machinery," O. F. Bartoo, 6.30 p.m.
Wed., Feb. 19.—NORTH EASTERN SECTION: Eldon Grill, Grey Street, Newcastle, "Recent Developments in Polythene," H. A. Rigby, 7 p.m.
Fri., Feb. 21.—MIDLANDS SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, 3, "Industrial Designs for Plastics," A. H. Woodfull, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Feb. 18.—SECTION LECTURE: Library, 4, Hamilton Place, London, W.1, "Aeroelastic Problems Associated with High Speeds and High Temperature," E. G. Broadbent, 7 p.m.
Thurs., Feb. 20.—HALTON BRANCH: Burnett Gymnasium, Halton Camp, First Trenchard Memorial Lecture, Sir Dermot Boyle, 6.45 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Thurs., Feb. 20.—12, Great George Street, London, S.W.1, "Housing for Special Needs," P. L. Leigh-Breese, 5.45 p.m.

ROYAL SOCIETY

Thurs., Feb. 20.—Burlington House, Piccadilly, London, W.1, "Recent Advances in Nuclear Physics," R. E. Peierls, D. H. Wilkinson and W. E. Burcham, 4.30 p.m.

ROYAL SOCIETY OF ARTS

Wed., Feb. 19.—John Adam Street, Adelphi, London, W.C.2, "Rocket Propulsion," J. E. P. Dunning, 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Wed., Feb. 19.—London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, "Research in Statistics," M. G. Kendall, 5.15 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Mon., Feb. 17.—Engineering Lecture Theatre, The University, St. George's Square, Sheffield, "Low Carbon Bainitic Steels," K. J. Irvine, 7.30 p.m.
Tues., Feb. 18.—B.I.S.R.A., Hoyle Street, Sheffield, "Penetrant Methods of Inspection," R. Schnurmann, 7 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Mon., Feb. 17.—PESTICIDES GROUP AND CORROSION GROUP: 14, Belgrave Square, London, S.W.1, "Corrosion of Spraying and Dusting Machinery," R. J. Coursbee, 6 p.m.
Thurs., Feb. 20.—ROAD AND BUILDING MATERIALS GROUP: 14, Belgrave Square, London, W.1, "Direct Observation of High-Temperature Processes with the Microscope," J. H. Welch, 6 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., Feb. 20.—Institute Buildings, Park Place, Cardiff, "The Breaking of Coal by High Pressure Compressed Air," P. G. Weekes and A. M. Watkins, 6 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, Feb. 14.—39, Elmbank Crescent, Glasgow, C.2, "High-Temperature Testing," J. Glen, 6.45 p.m.

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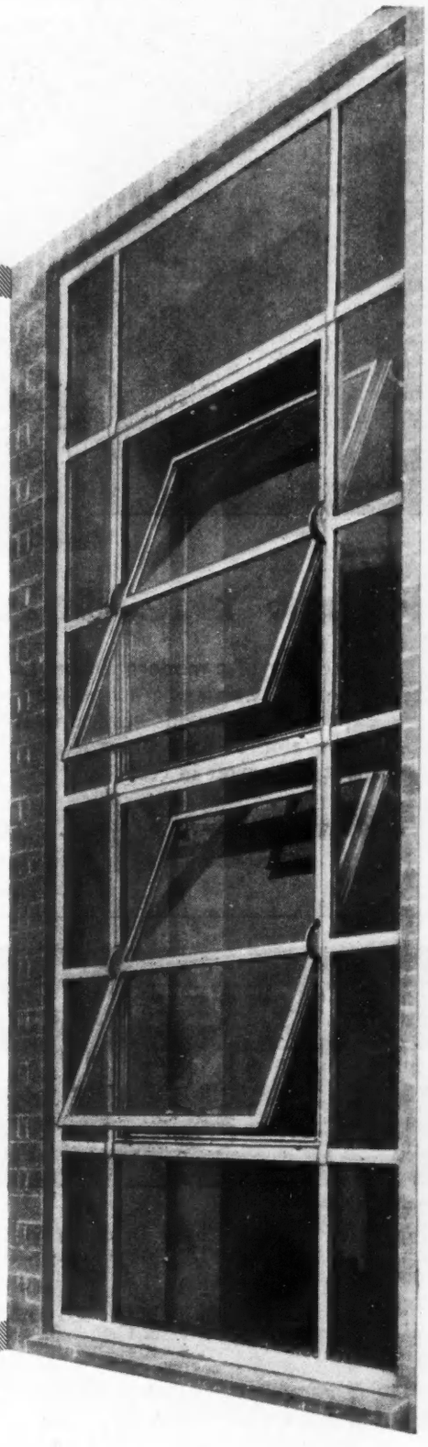

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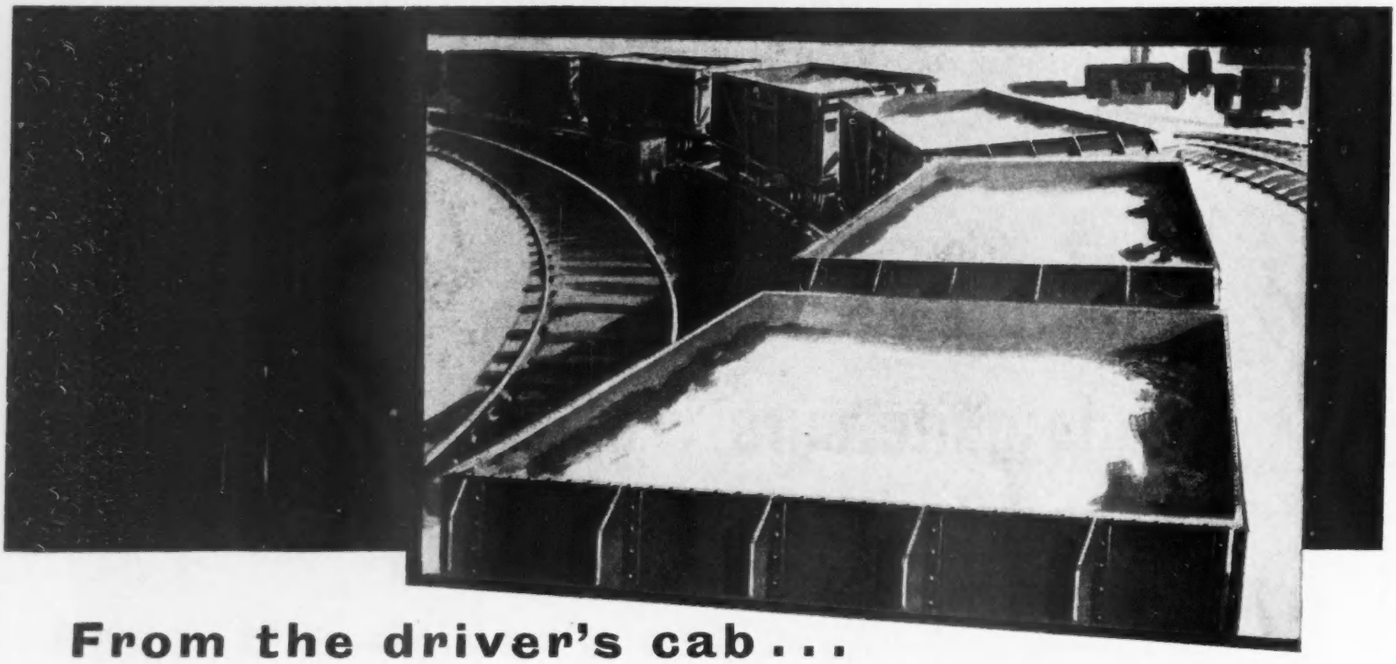

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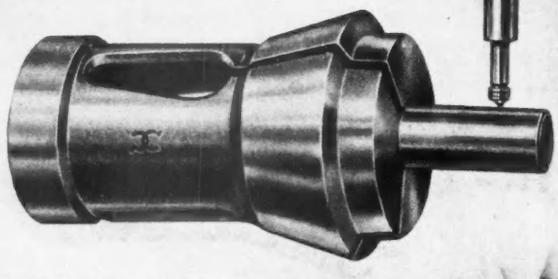

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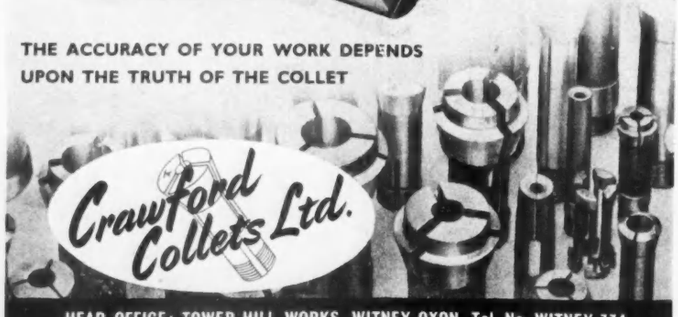

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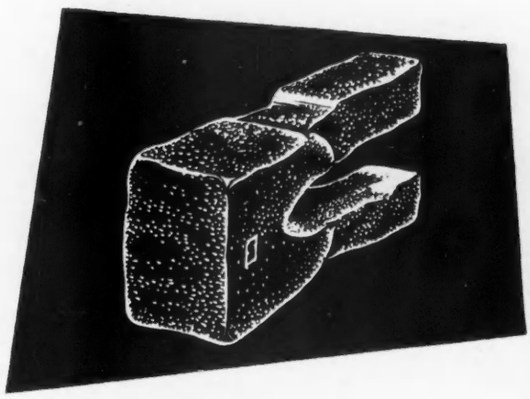

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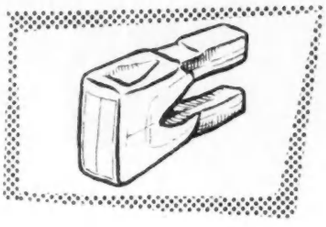

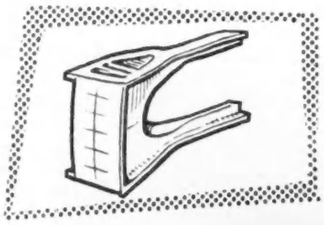

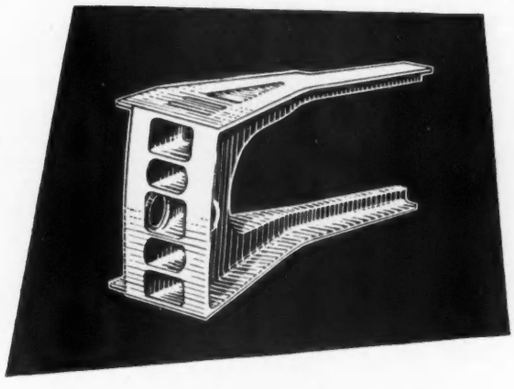

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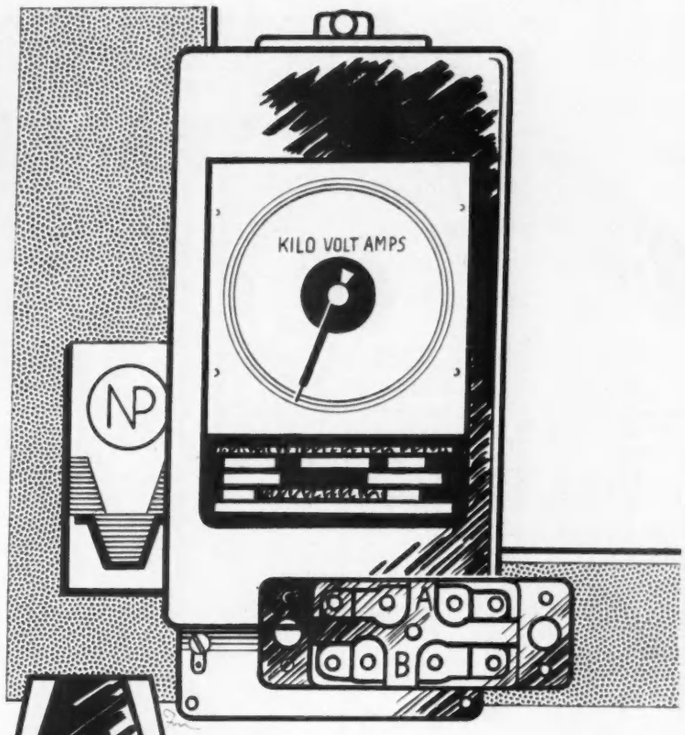

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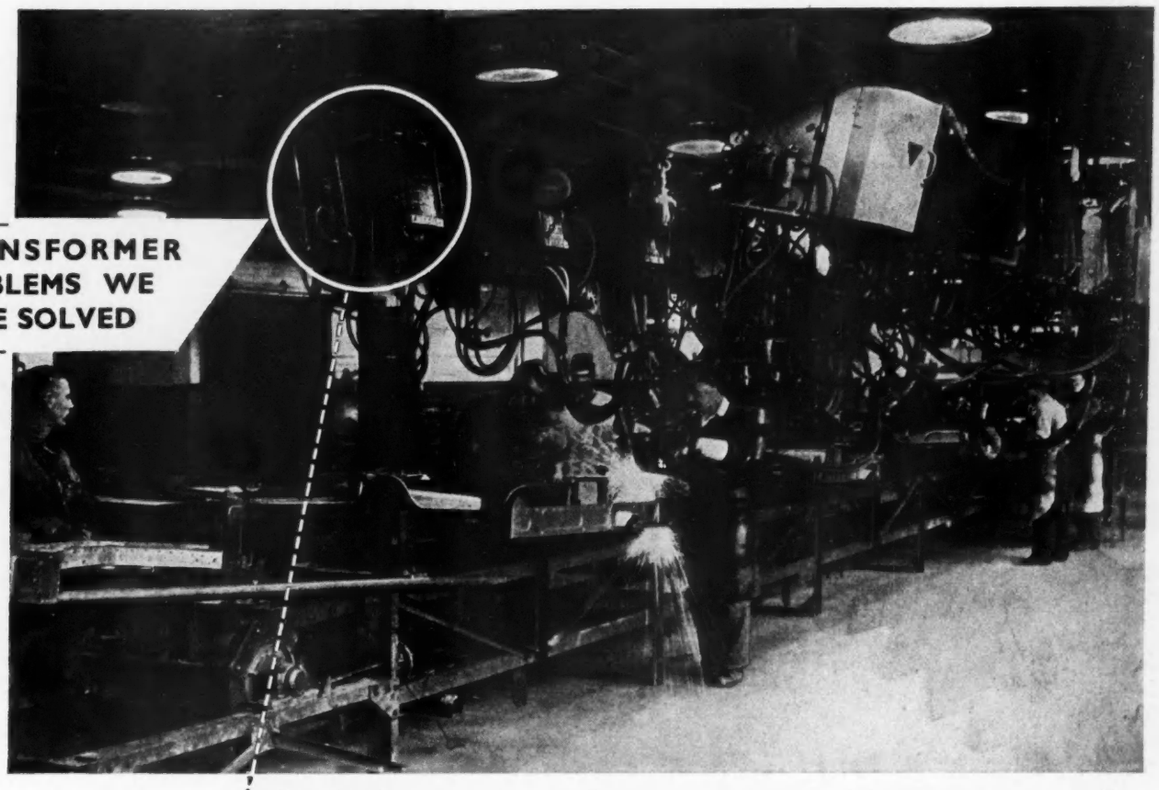

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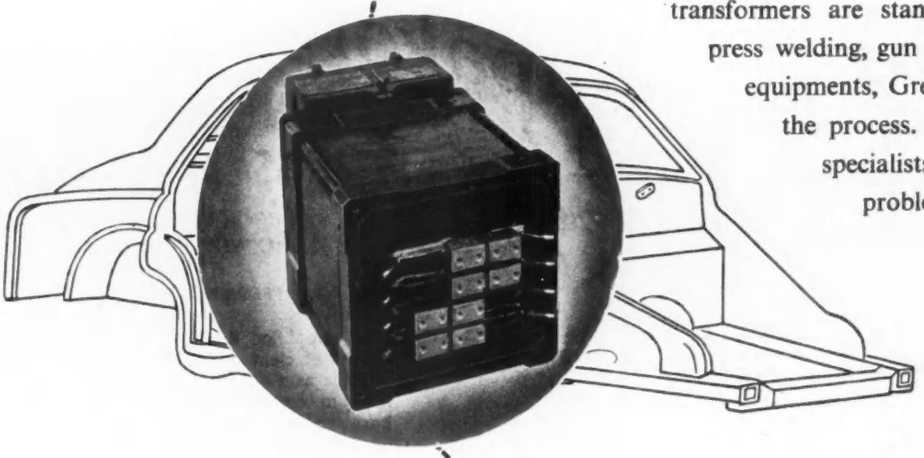

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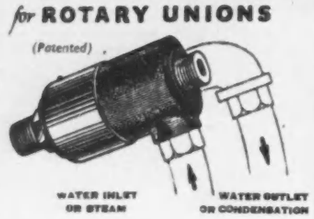

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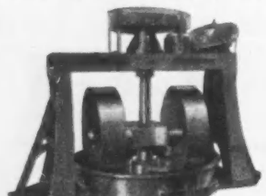

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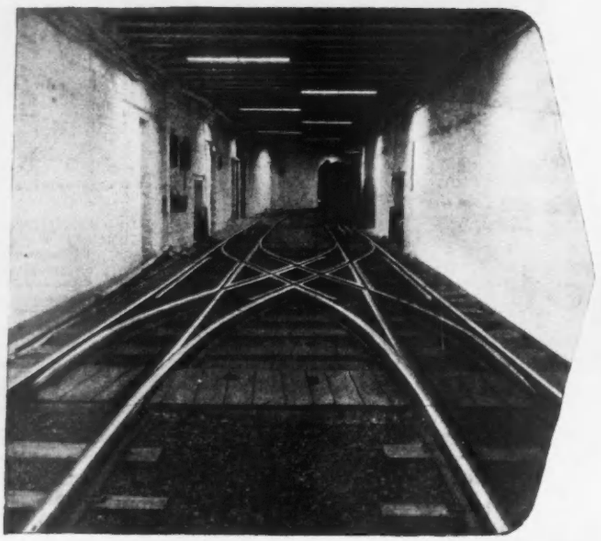

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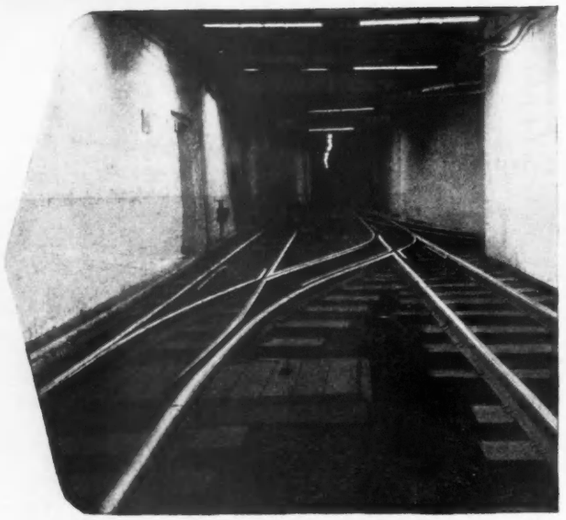

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SPECIALISTS IN FABRICATED MACHINERY
General Sheet Metal Workers

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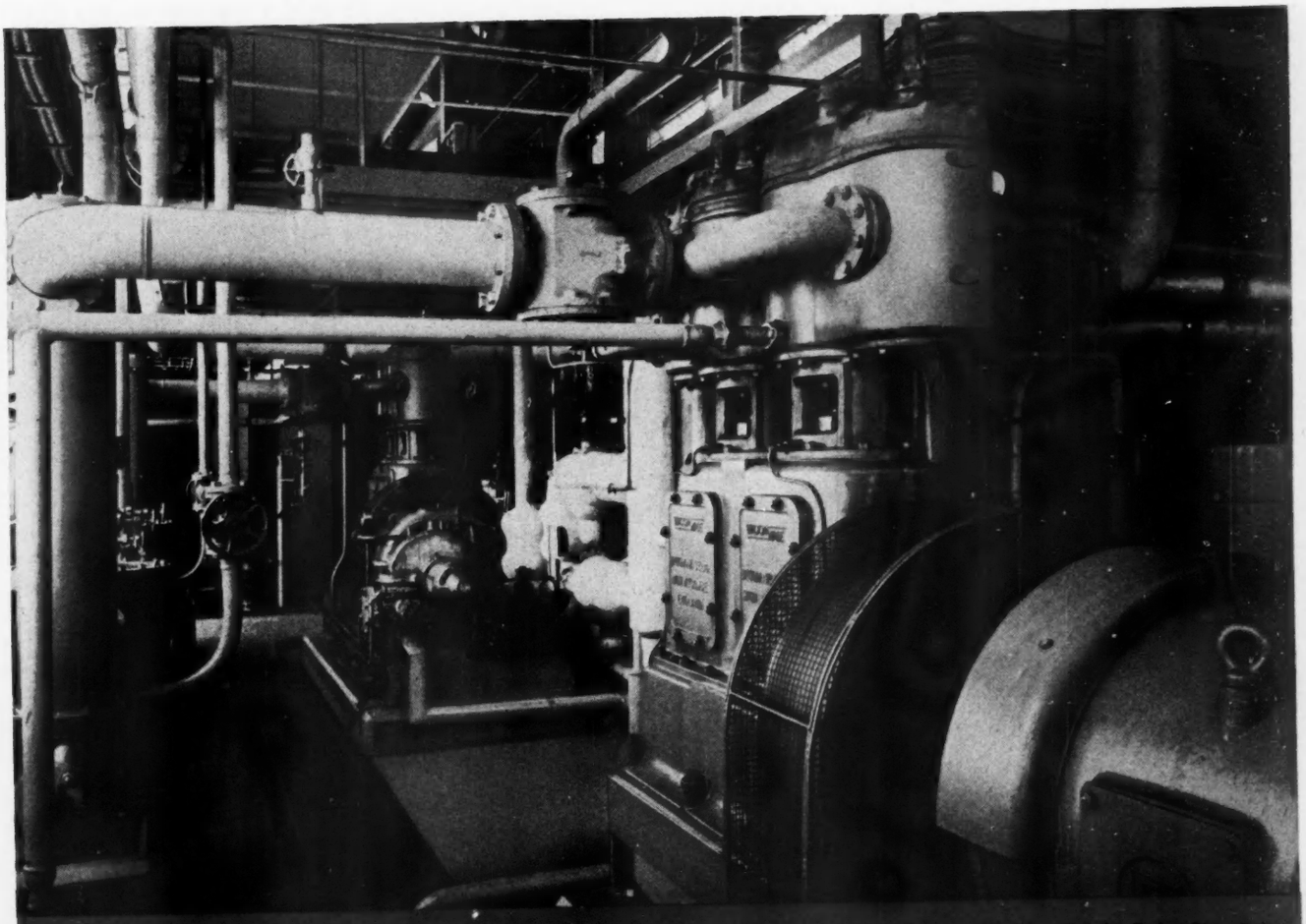

Two type SSL4 Six-Cylinder Carbon-Ring Single-Stage Air Compressors, installed at Kurnell Oil Refinery, Botany Bay, New South Wales. (Photograph by courtesy of Australian Oil Refineries Ltd.)

"BROOMWADE"
oil-free compressed air at Botany Bay

In food manufacture, chemical processing, instrument control, diving apparatus and the like, OIL-FREE AIR is essential. To meet this requirement, the "BROOMWADE" dry-cylinder, carbon-ring air compressor is ideal.

Delivery of OIL-FREE air can be obtained only from VERTICAL, double-acting machines, for only in such units can the essential carbon-rings be employed.

Simple design, slow speeds and adequate cooling ensure high efficiency. Constant research and development are maintaining the "BROOMWADE" reputation for EFFICIENCY and RELIABILITY throughout the world.

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BROOM & WADE LTD., P.O. BOX No. 7, HIGH WYCOMBE, ENGLAND

Telephone: High Wycombe 1630 (10 lines) Telegrams: "Broom," High Wycombe

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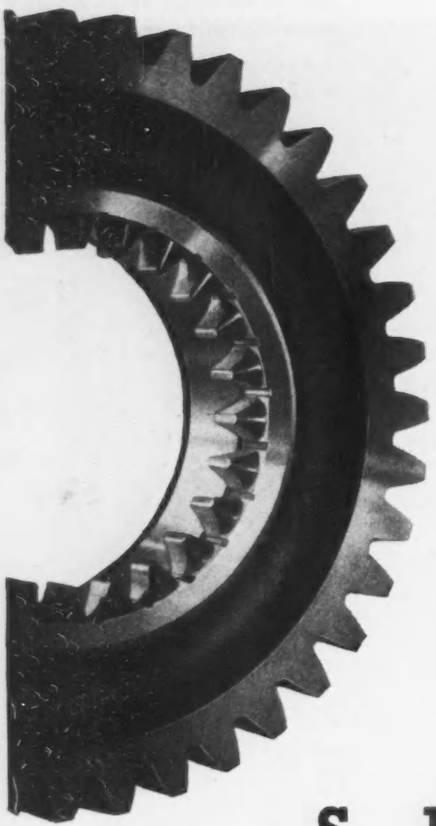

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New simplified design incorporating the highly efficient "Supakone" Joint—obtainable as a simple shut-off valve or as a medium control valve. Standard valves, both straight through and right angle types are suitable for hydraulic working pressures up to 10,0000lbs. per sq. in. at normal temperatures—individually tested to 15,000lbs. per sq. in. hydraulic. We also manufacture a neat well designed valve suitable for controlling gauge circuits or small hydraulic installations working at pressures up to 2,000lbs. per sq. in. hydraulic.

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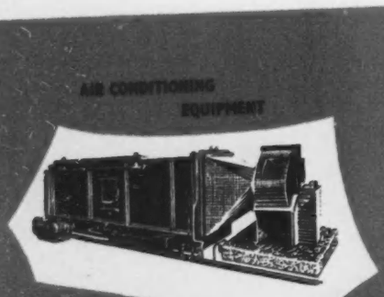
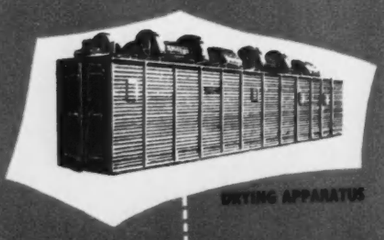
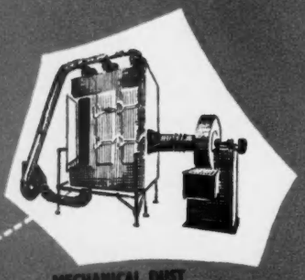

AIR CONDITIONING EQUIPMENT


DRYING APPARATUS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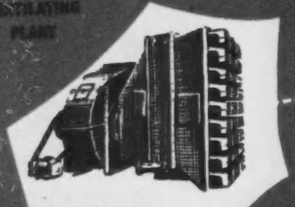
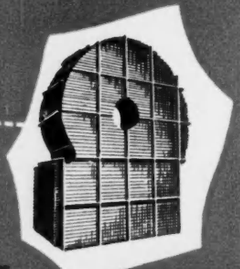
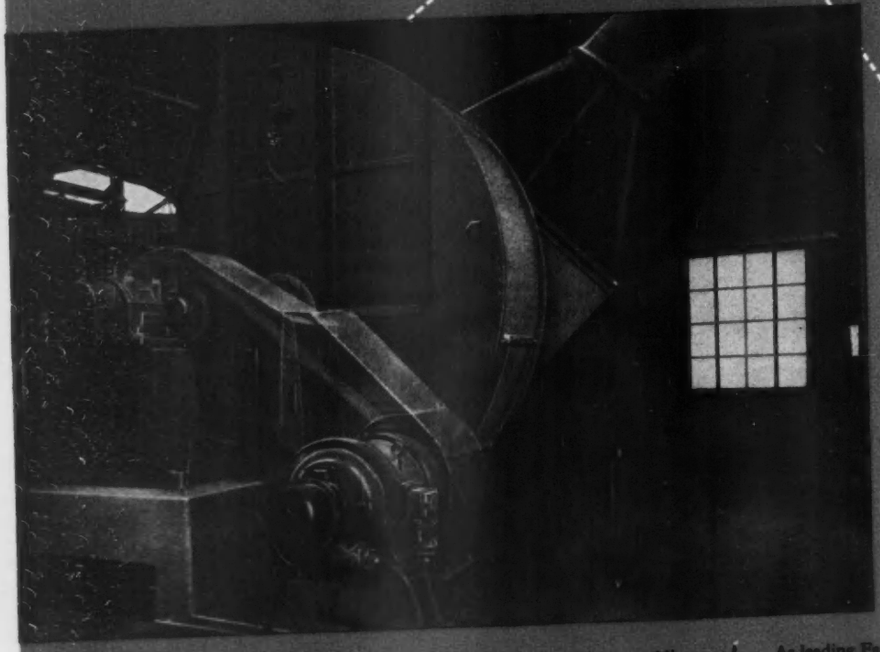


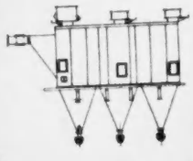
Musgrave manufactures


FANS FOR ALL PURPOSES



HEAVY STEEL FABRICATION

S.F. ELECTRIC PRECIPITATORS



A Musgrave 96" dia. "L" type Backward Curved Fan, providing Induced Draft for a Wet Process Cement Kiln. This fan is capable of 121,000 c.f.m. at a temperature of 490°F. against a static suction of 8.5" W.G. and requiring 247 H.P. nett, to drive.

For Induced Draft on a Cement Kiln is is desirable to choose a Fan with a non-overloading power characteristic to cope with varying Kiln operating conditions: — a steep pressure characteristic to give smooth and sensitive reaction to fan control from the firing floor, and a high efficiency to reduce operating costs. The Musgrave Backward Curved Impeller satisfies these requirements, but as the gases are often dusty, and contain a high moisture content, special attention must be given to the fan design to counter the twin-problems of dust build-up and abrasion.

As leading Fan Manufacturers, our experience is considerable in this particular field of Engineering, and in recent years our Aerofoil Backward Curved Fan has been successfully applied where higher efficiency; reduction in build-up and improved resistance to abrasion are first considerations. Our Manufactures include other plant for Cement Works applications: such as fans for Fuel Firing, Clinker Cooling, and Forced Draft—we also manufacture a complete range of dust collecting equipment — Cyclones : Aerodynamic Collectors : Wet Scrubbers : Bag Filters : Musgrave-Neu Automatic Bag Filters and the Musgrave-S.F. Electric Precipitators.

Our Technical Staff will be please to offer a solution to your particular problem.

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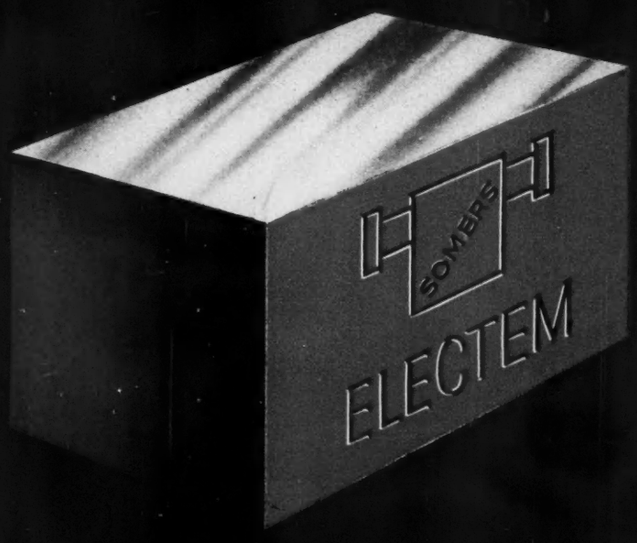
DIE BLOCKS



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Steels *from the* Brown Lenox *foundry*

3 • • • • • • • • • • • BS 1617: Grades A and B

This steel composition is one which is used for large numbers of steel castings which are required to possess a high degree of magnetic permeability. Such steel castings are used for electrical and general engineering purposes. This particular steel is produced in two grades, A and B, which grades are distinguished by their carbon content, and mechanical properties, which are indicated in the accompanying table.

British Standard Year of Issue			1617 1950	
Description			Mild Steel Castings of High Magnetic Permeability	
Grade			A	B
Chemical Composition	Carbon %	maximum	0.15	0.25
	Silicon %	„	0.60	0.60
	Manganese %	„	0.50	0.50
	Nickel %	„	—	—
	Chromium %	„	—	—
	Molybdenum %	„	—	—
	Sulphur %	„	0.06	0.06
	Phosphorus %	„	0.06	0.06
Mechanical Properties	U.T.S. tons/□″ not less than		28 max.	26-32
	Yield Stress or 0.5% Proof Stress	„ „	—	13
	Elongation %	„ „	22	20
	Red'n. Area %	„ „	—	—
	Izod ft. lbs.	„ „	—	—
	Angle of Bend	„ „	120°	120°
	Brinell No.		—	—
Equivalent Specifications	American Society for Testing Materials	A27-52T	—	—
		A148-50T	—	—
		A217-49T	—	—
		Others	—	—
	Society of Automotive Engineers		—	—
	B.S.1504 : 1950		—	—
	D.I.N. (German)	1681	GS-38.9	GS-45.9
		17245	—	—

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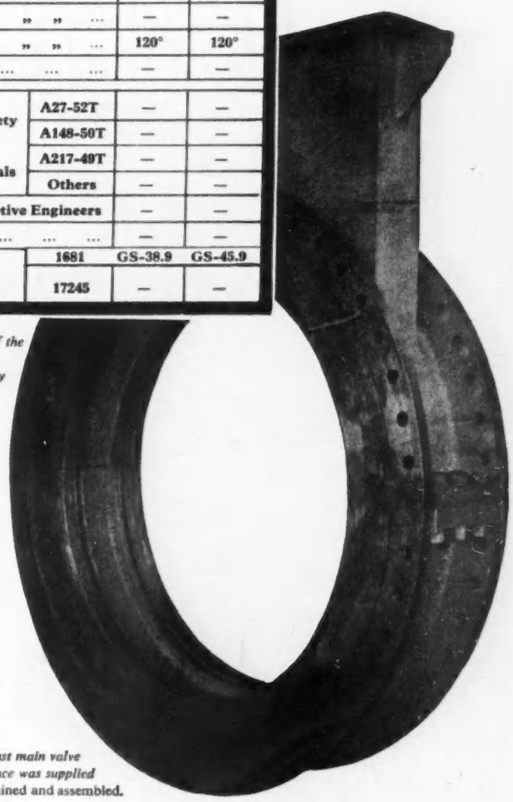
SUB-ASSEMBLIES

In No. 2 of this series of announcements we remarked upon the advantages to be derived from ordering steel castings to be supplied finish-machined, or part-machined.

To take this matter of the condition in which steel castings are purchased, a stage further, here we are concerned with component sub-assemblies.

By supplying two or more *cast steel* components finish-machined, and con-joined by bolting or weldments, a steel founder may enable his customer to effect further economies in production costs.

This is especially so when a particular sub-assembly, or its individual *cast steel* component-parts, are smaller, or larger, or for some other reason not suited to the purchaser's plant, or his assembly and machining set-ups.



This cast steel hot blast main valve body for a blast furnace was supplied to our customer machined and assembled.

An announcement by the Industrial Division of

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Associated Company: Brown, Lenox & Co. (London) Ltd., Millwall, E.14
PONTYPRIDD GLAMORGAN

N

PUMPS & MOTORS

779

Three Mather & Platt high-speed Plurovane pumps working in conjunction with air-pressurised hydraulic accumulators in a large steel works. Each pump is capable of dealing with 300 g.p.m., 835 p.s.i., and is driven by a Mather & Platt drip-proof squirrel-cage induction motor, rated at 275 b.h.p., 2750v., 2930 r.p.m., direct-on started with a low starting current. The sets are arranged for automatic operation.

Mather & Platt
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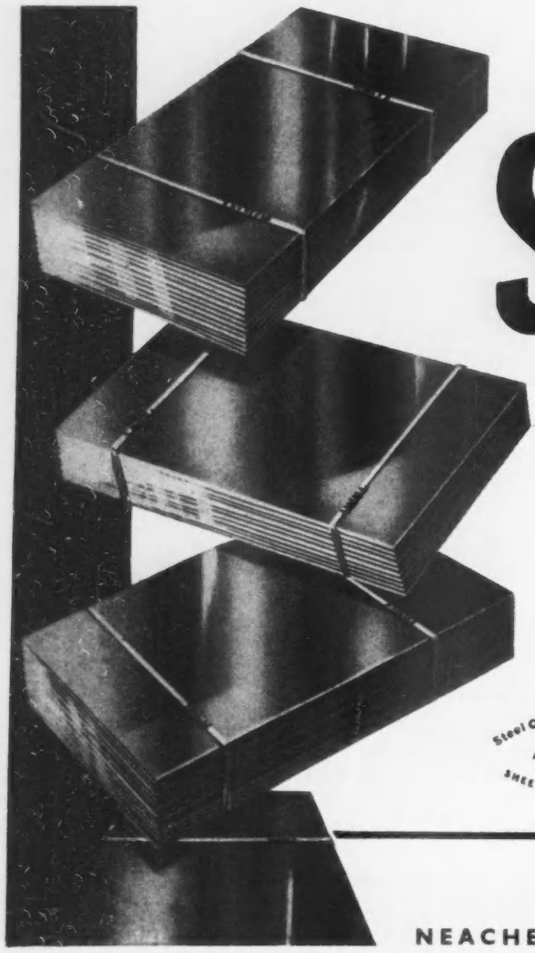
Telegrams: Mather, Manchester



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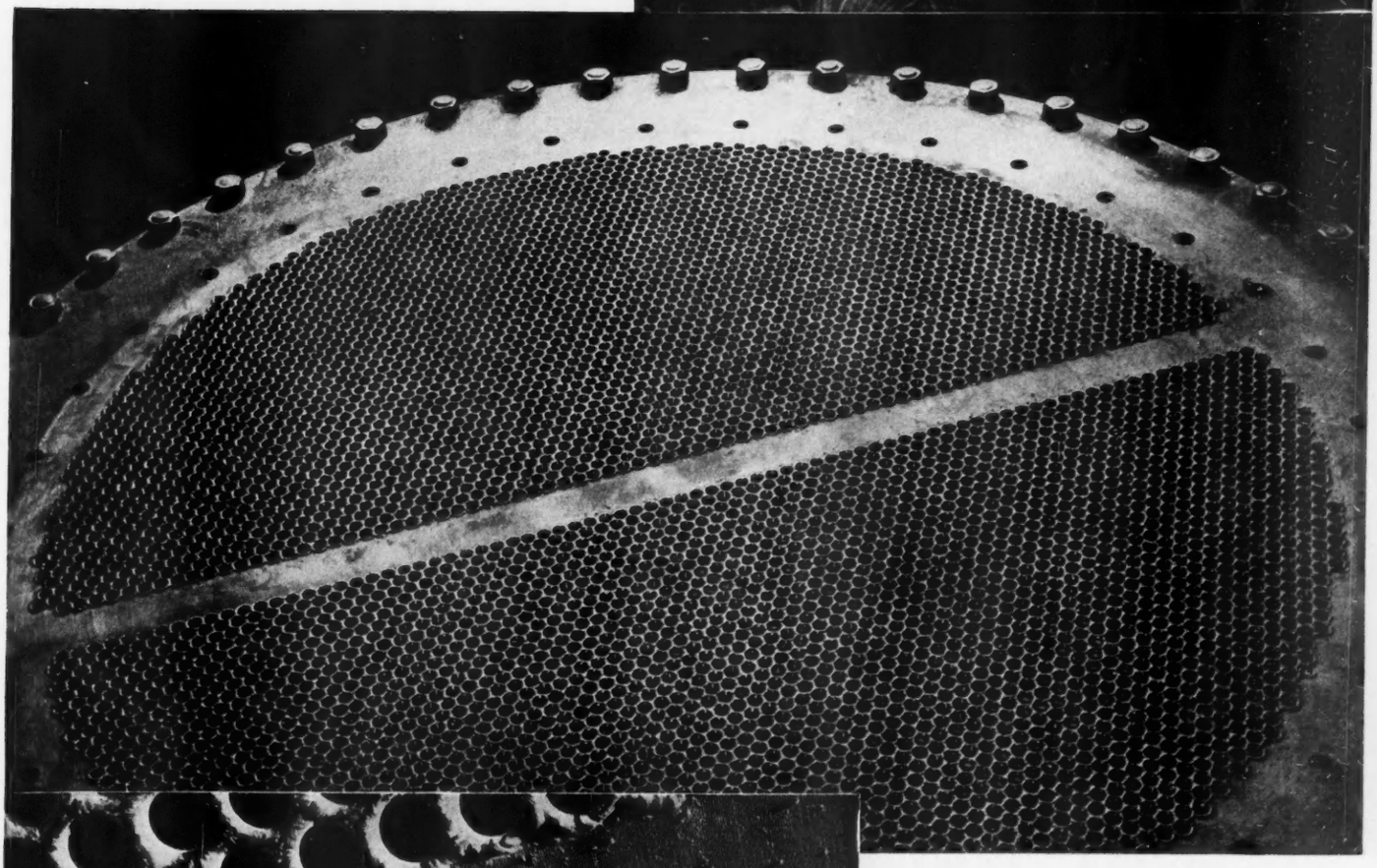

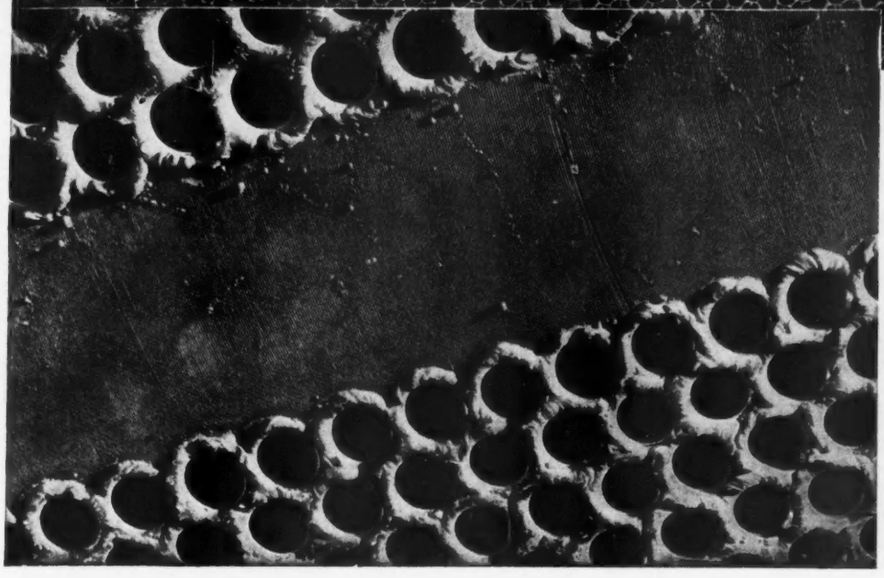

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Hydraulic Control of motion

Paradoxically, the product of human skill is more accurate than human skill itself. This is particularly so in the case of Savery Hydraulic Pumps. Countless thousands of Savery Pumps are in use throughout the world working with precision that neither human skill nor other means can match. Next time you're considering control of motion remember Savery Hydraulic Pumps first. Savery Pumps can be supplied with fixed or variable delivery.

FOR FURTHER DETAILS OF

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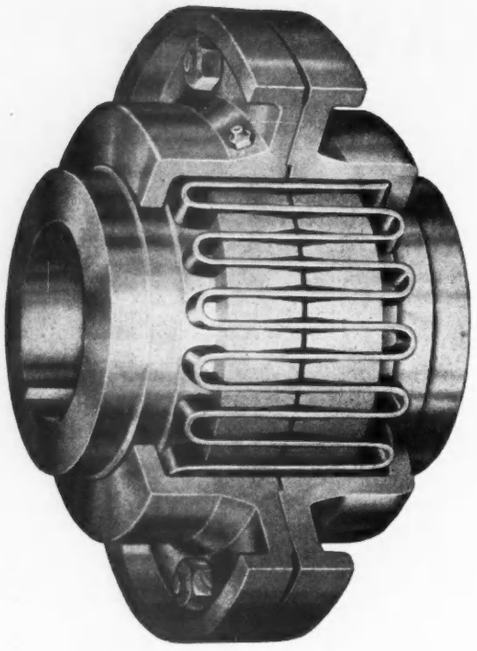

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Sugden Superheaters are of particular value where auxiliary steam boilers are used.

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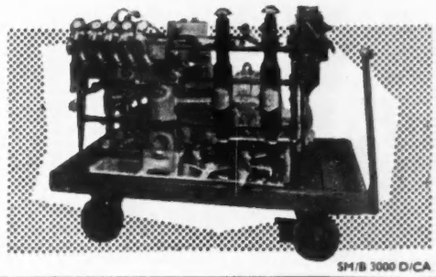
Wing flaps, undercarriage and servo-mechanisms in the "Whispering Giant" are actuated by air from high pressure bottles. Birlec compressed air dryers ensure maximum safety and efficiency by removing harmful moisture vapour to prevent freezing at the release valves as expansion takes place.
Backed by over fifteen years specialised development, Birlec compressed air dryers are currently in use for a wide selection of industrial applications employing pressures ranging from 100 to 6000 p.s.i. Fully automatic and modest in running cost, Birlec drying equipment contributes to the efficient operation of oil refineries, chemical plants and all types of moisture-sensitive pneumatic equipment and instruments throughout the world.

With acknowledgments to B.O.A.C., The Bristol Aeroplane Company Limited and Williams & James (Engineers) Limited.



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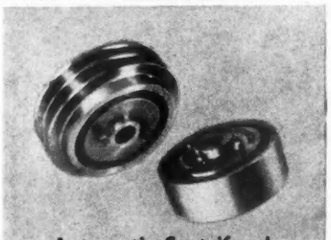
Multi-Plate Disc Type Friction Clutch



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Friction Clutches are our business—efficient in design, dependably made and backed by a service you can rely on.
Our long and specialised experience and technical 'know-how' ensure complete satisfaction to the user of Clutch Units made by

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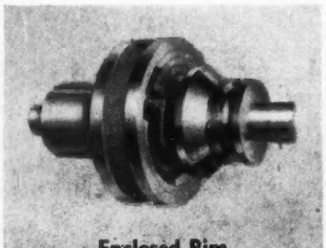
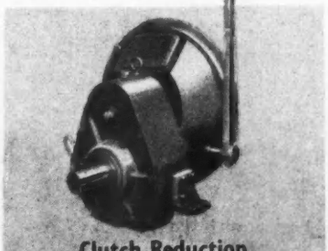


Enclosed Rim Friction Clutch



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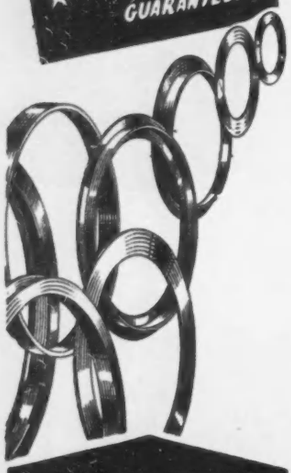

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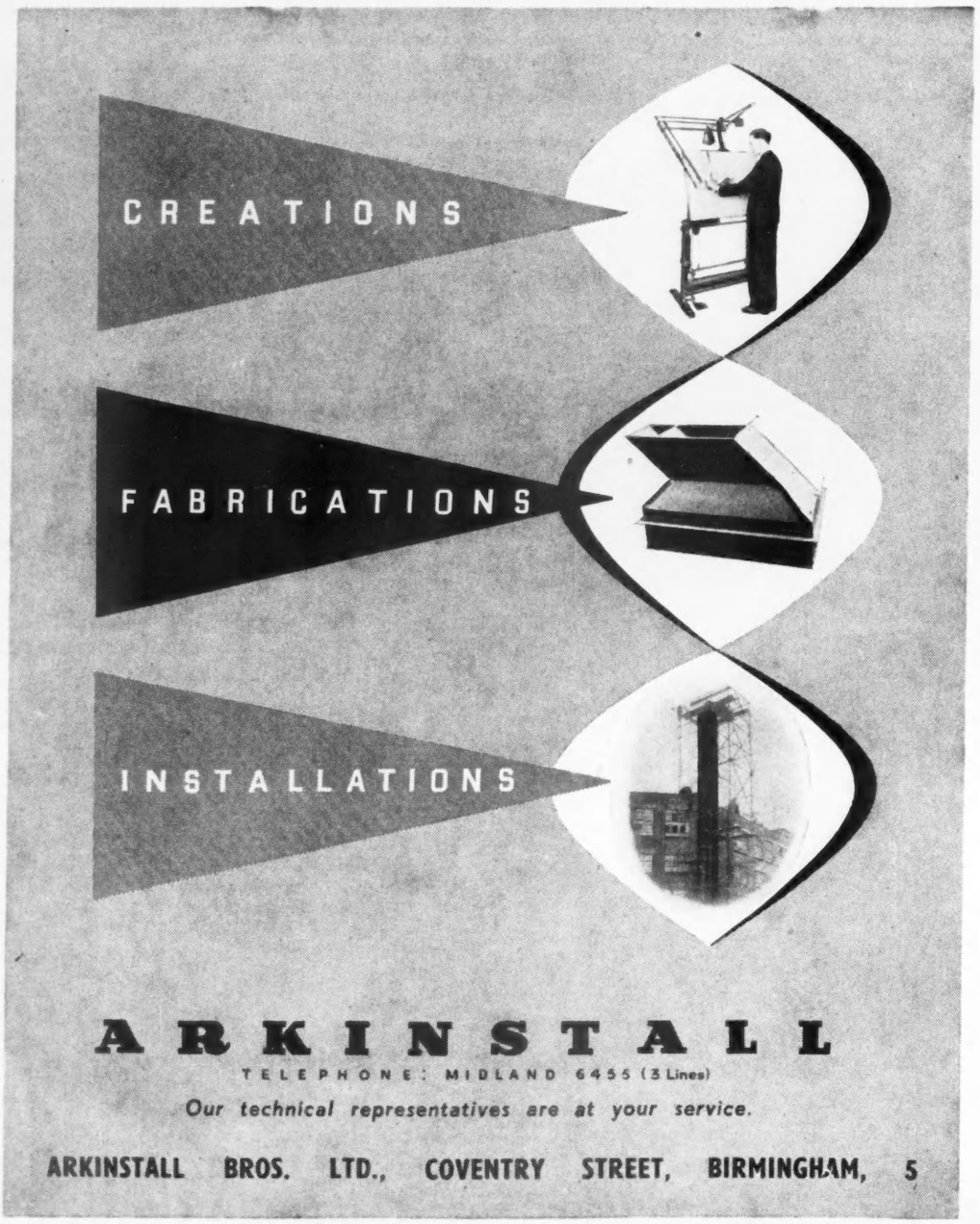

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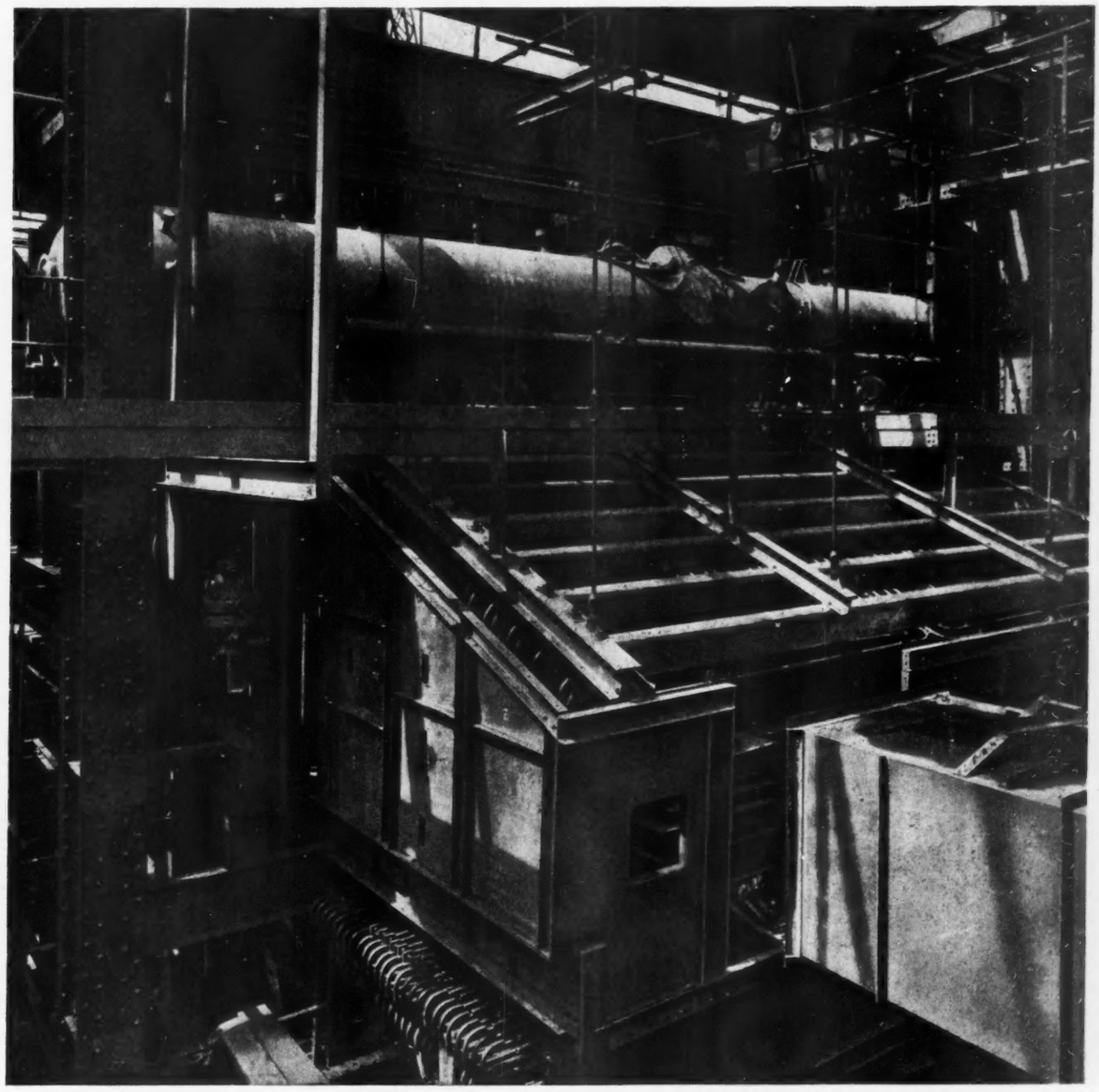

Here is erection proceeding at an installation of three 360,000 lb/hr steam generators with superheater outlet pressure of 940 lb. per sq. inch and a final steam temperature of 920 F.

The boilers were completed, tested, accepted and handed over for full duty well within the time specified.

Whitecrook is becoming an important source also for industrial boilers from 14,000 lb/hr to 150,000 lb/hr capacity complete with all ancillary equipments.

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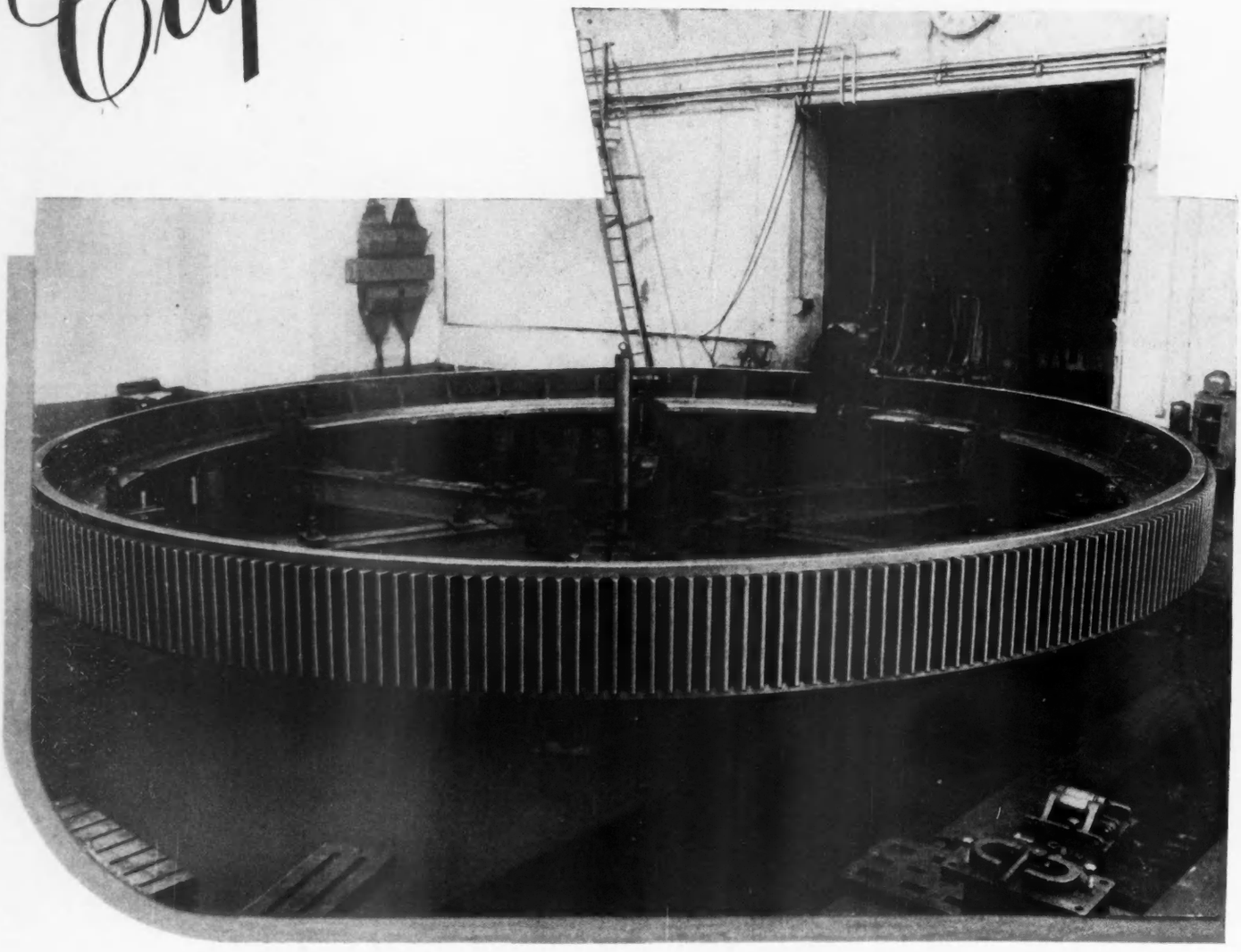
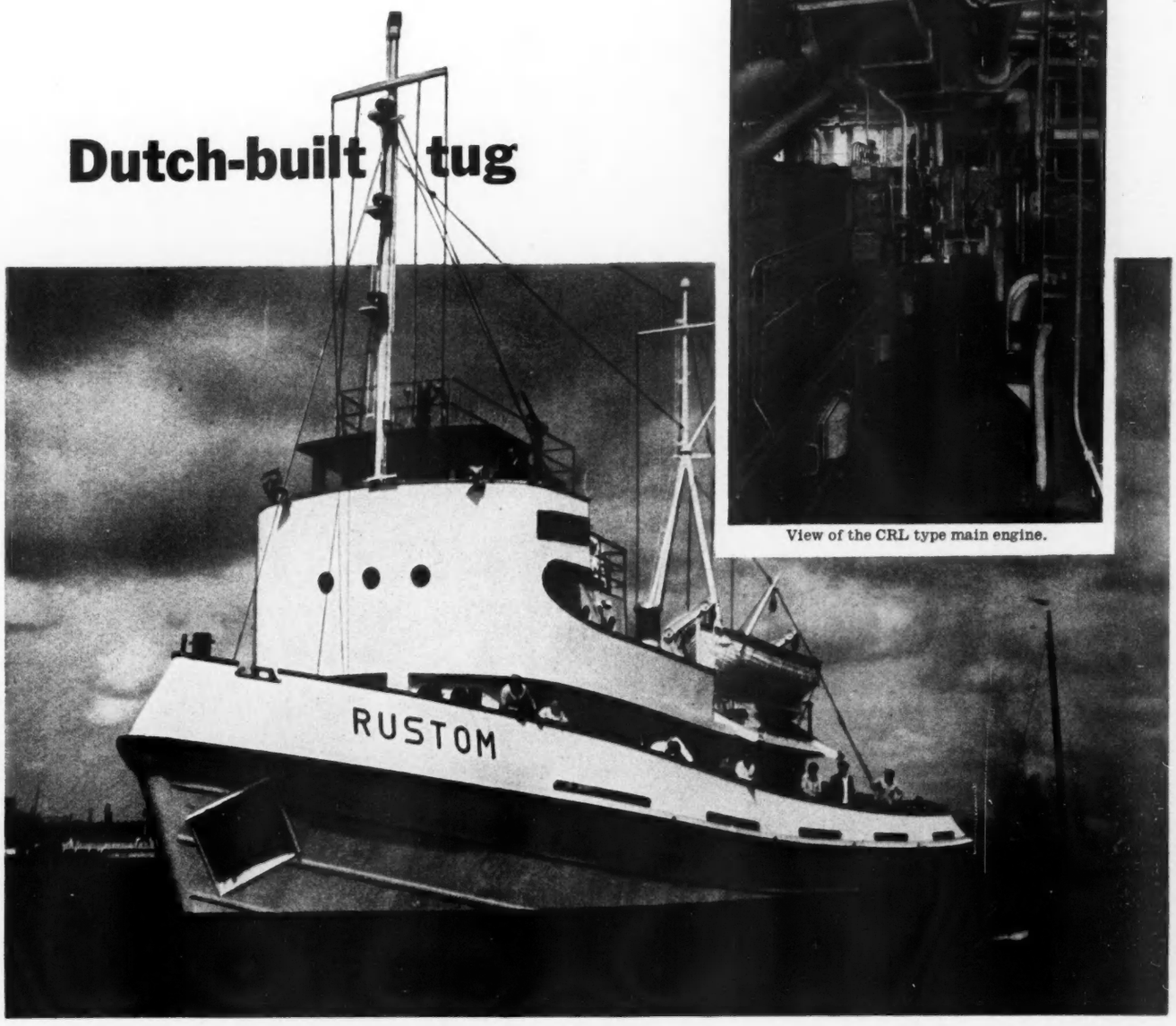


Cutting 26ft. Dia. spur ring on 30ft. machine.

THE
DAVID BROWN
CORPORATION (SALES) LIMITED
JACKSON DIVISION
SALFORD WORKS HAMPSON STREET
MANCHESTER 5

Dutch-built tug

View of the CRL type main engine.



for Pakistan

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The propulsion engine is a Crossley six-cylinder direct reversing Scavenge Pump Diesel Engine rated at 1100 b.h.p. at 320 revolutions per minute, giving a speed of over 10 knots.

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The MT *Rustom* which is an ocean-going tug, is employed for salvage, harbour and fire-fighting duties, and operates from Karachi.

CROSSLEY DIESEL ENGINES

C416

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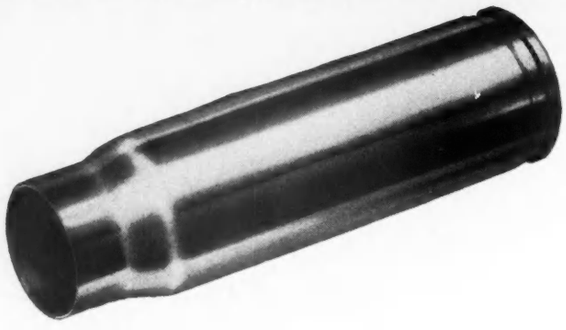
FORMING Titanium



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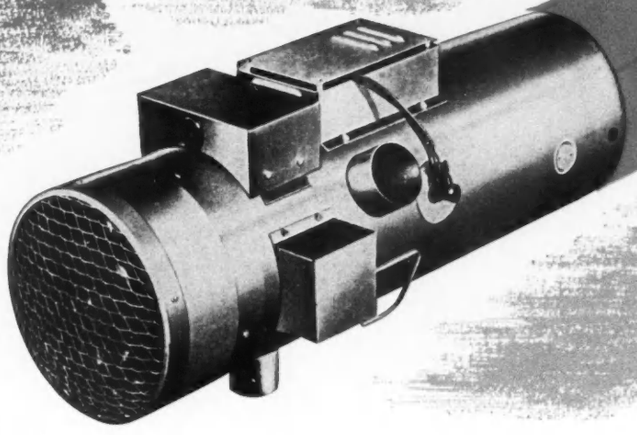

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Efficient	*Full heat in 4½ minutes.*
Simple	*One switch operates everything.*
Safe	*Automatic safety devices.*
Non-Toxic	*No combustion fumes circulate indoors.*
Versatile	*Gives full heat, reduced heat and also circulates cool air if required.*

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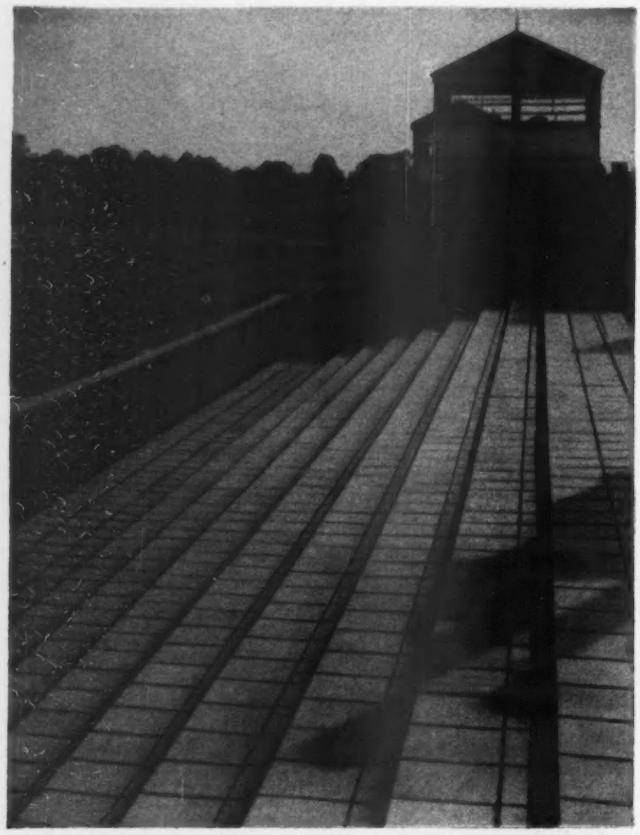
AP 230-(2



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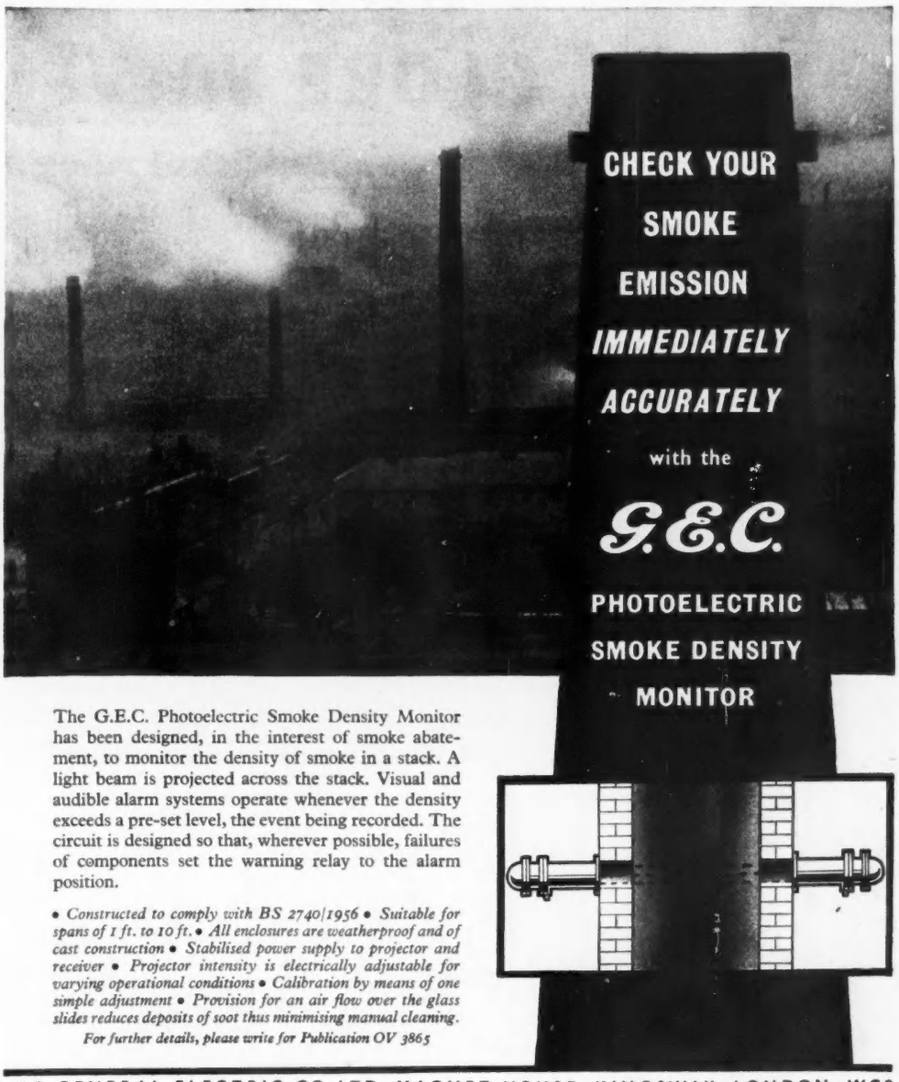

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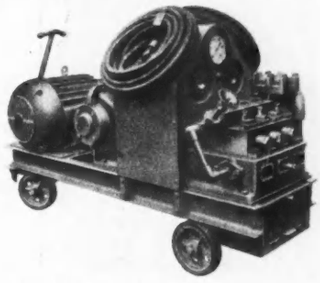

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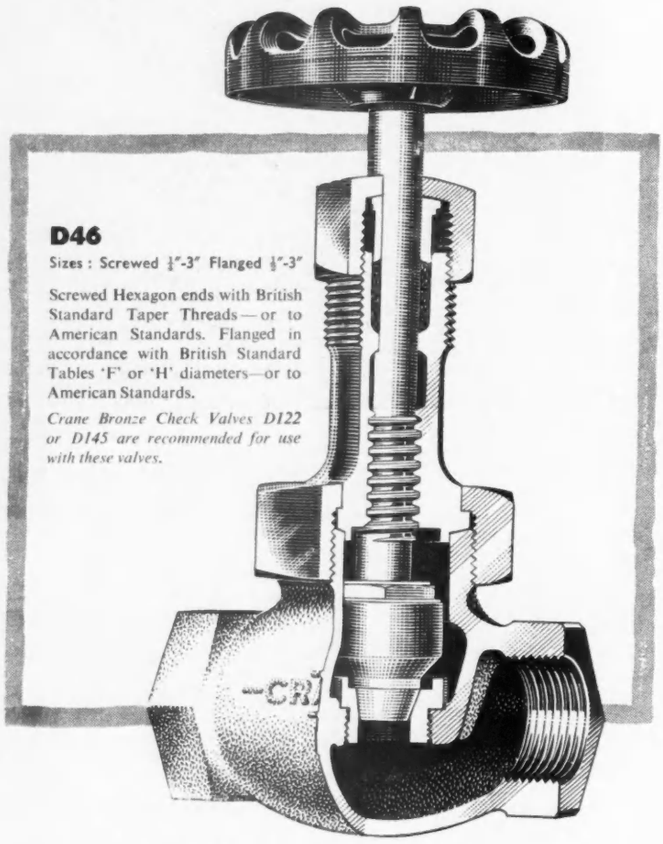

D46

Sizes : Screwed ¼"-3" Flanged ½"-3"

Screwed Hexagon ends with British Standard Taper Threads—or to American Standards. Flanged in accordance with British Standard Tables 'F' or 'H' diameters—or to American Standards.

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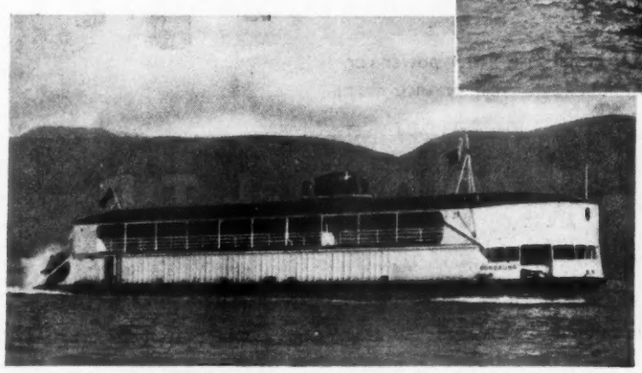

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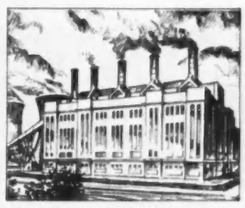

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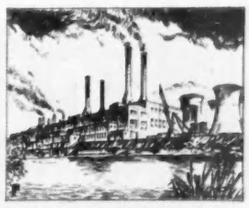

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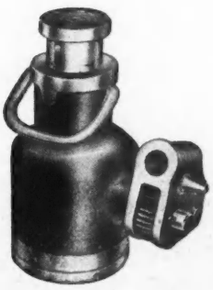

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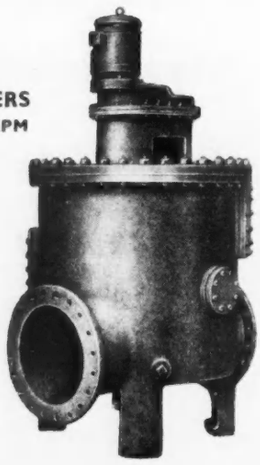

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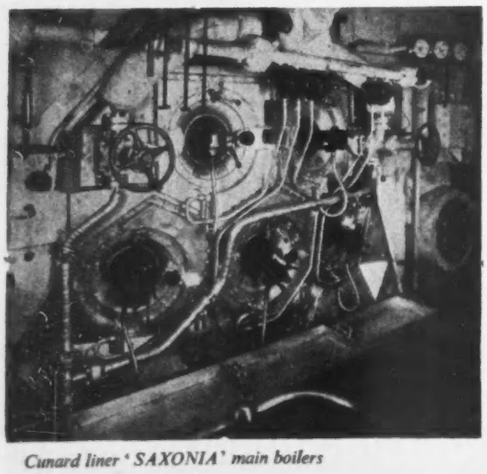

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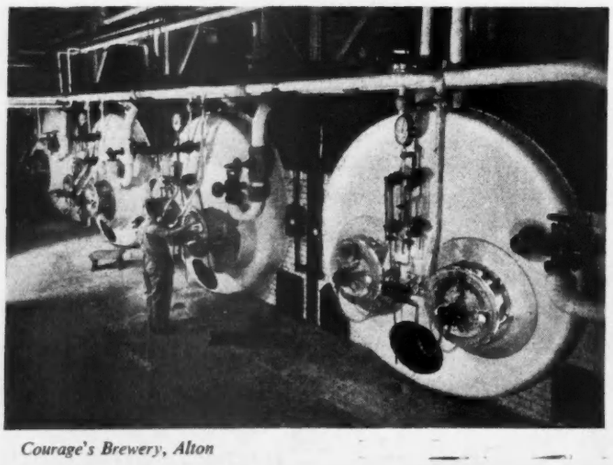

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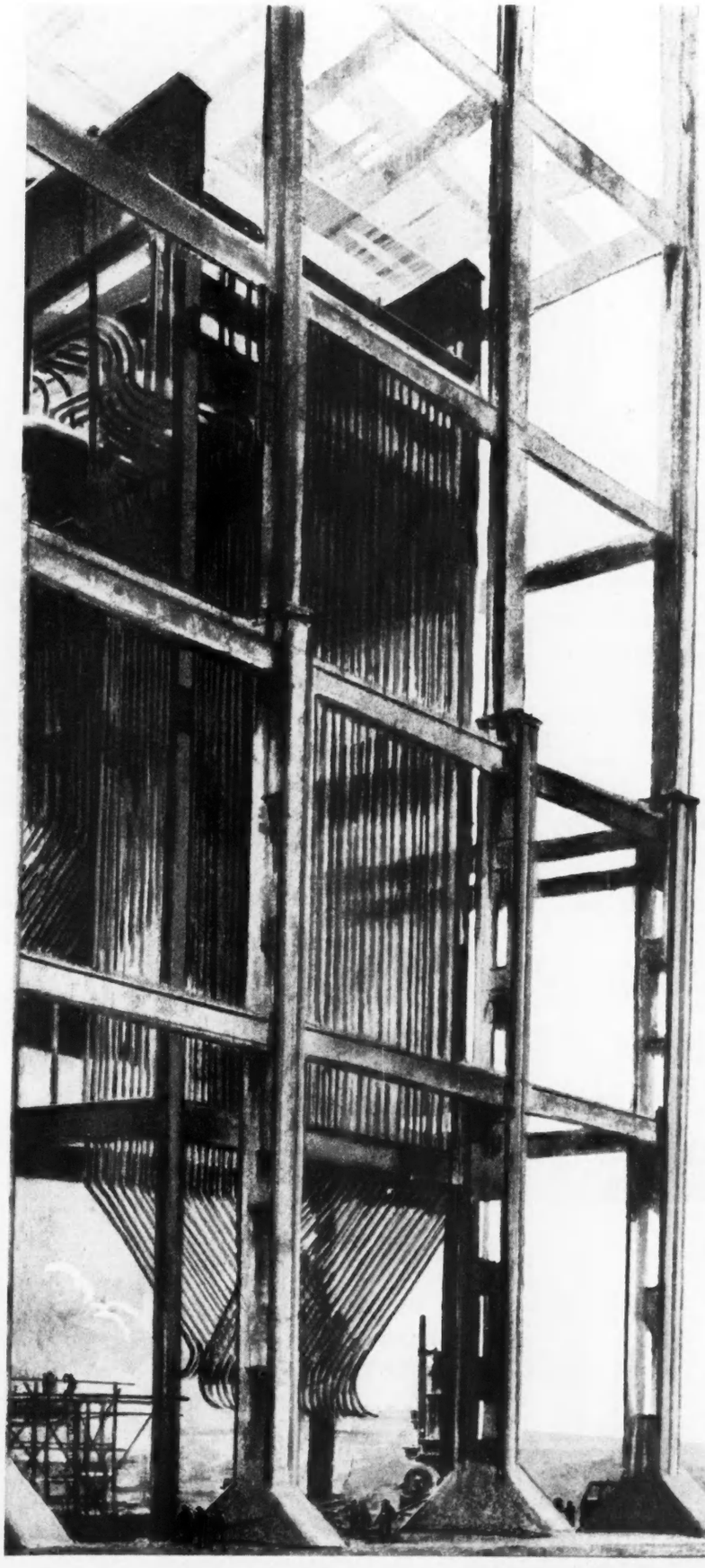

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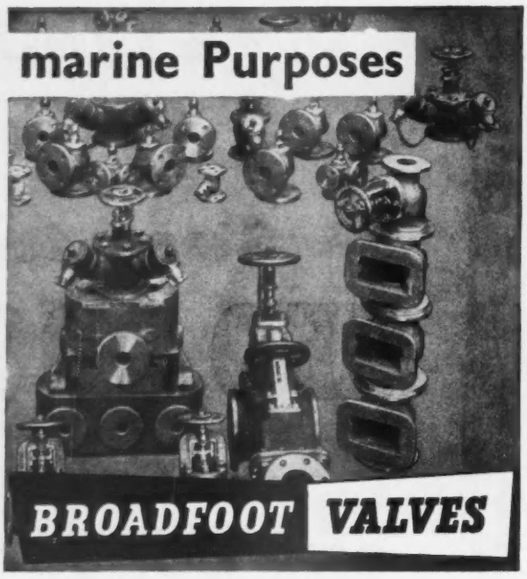

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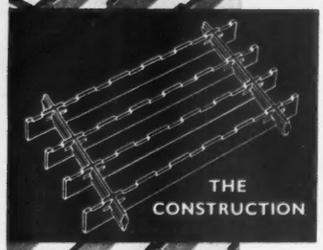

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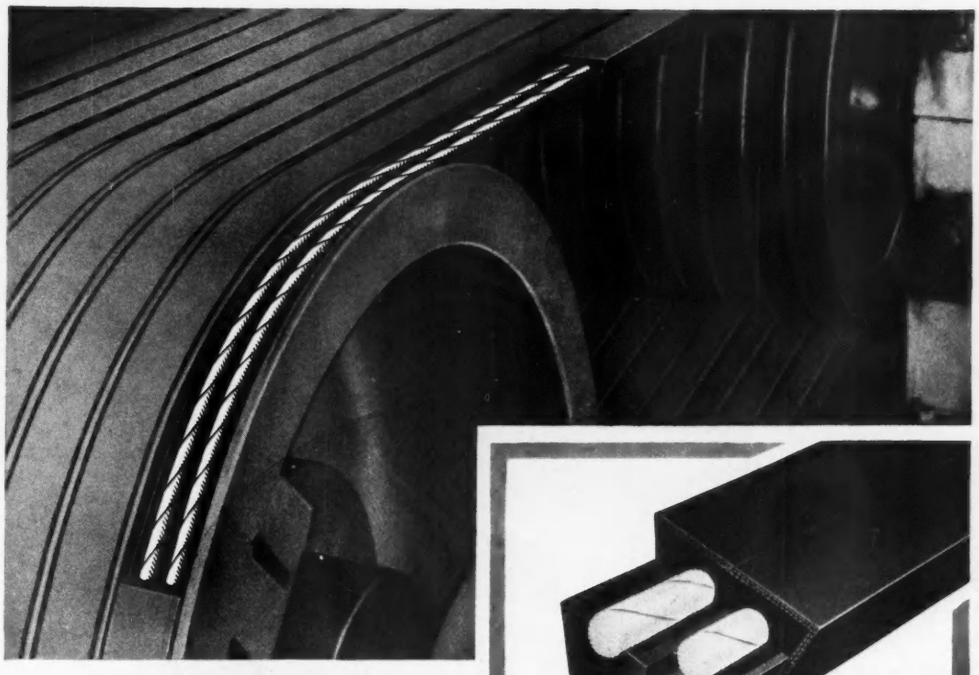

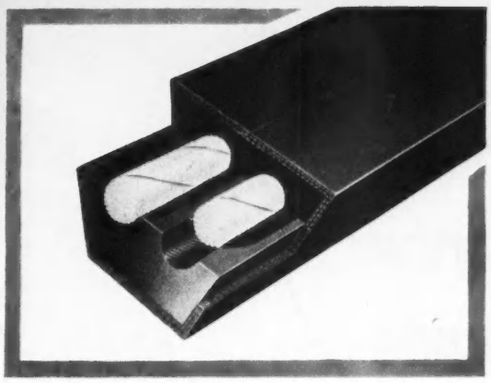

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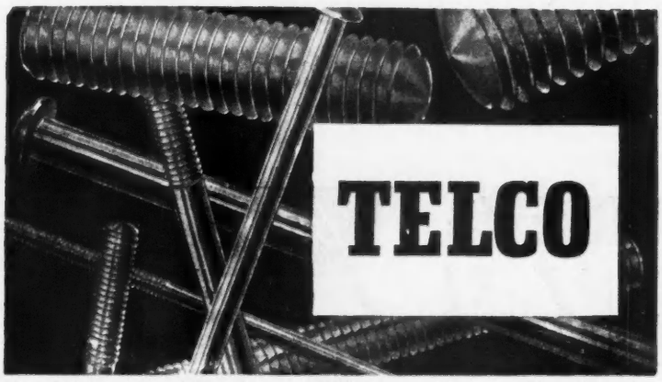

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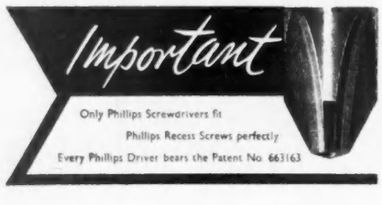
Important
Only Phillips Screwdrivers fit
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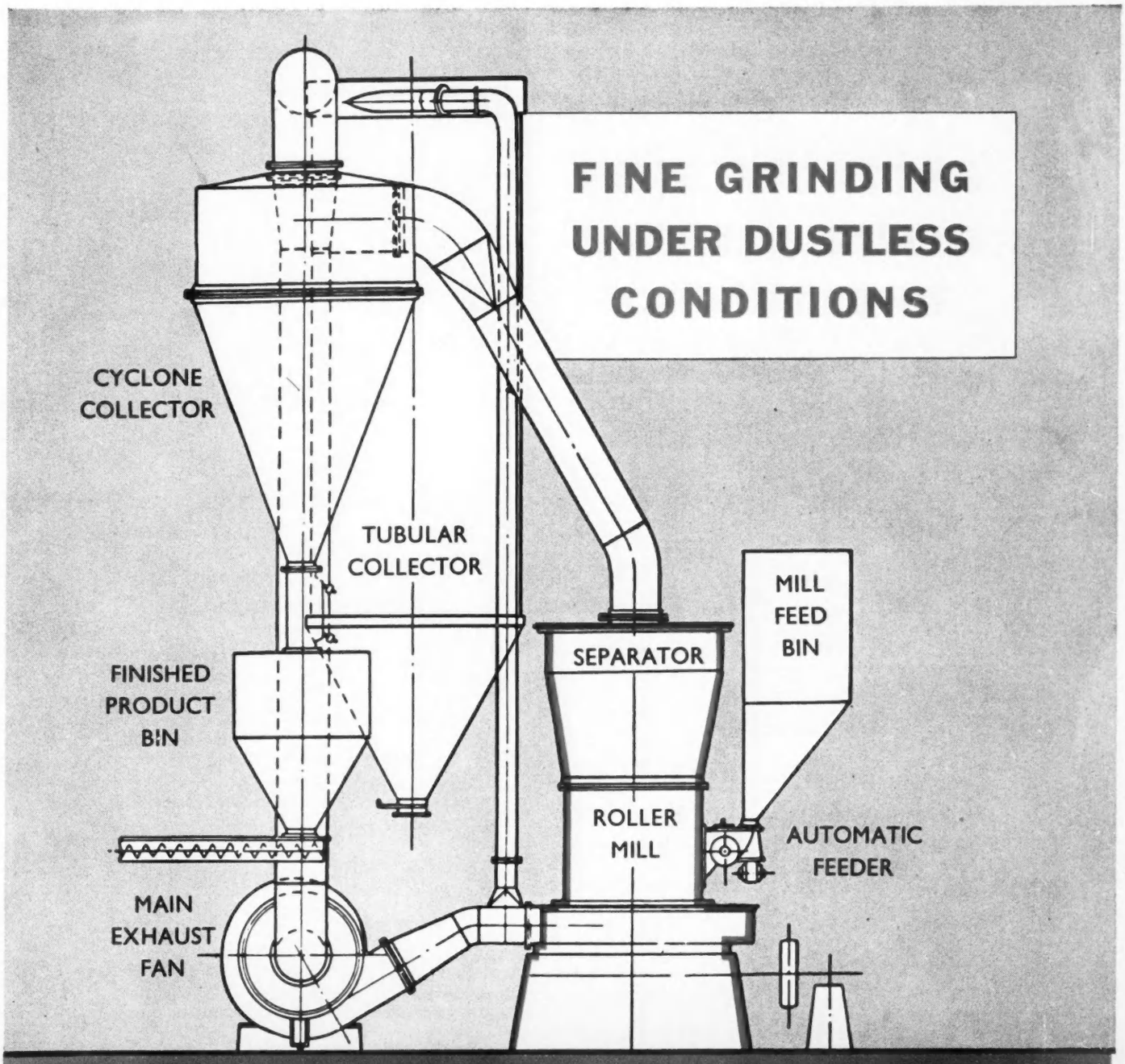

Grinding by centrifugal action of pendulum rollers against grinding ring • Automatic feeder and integral air classification system • Suction fan at floor-level draws the ground material to a separator and thence direct to a cyclone • Dustless pneumatic system conveys and collects product • High output of final ground material ranging to 325 mesh as desired.

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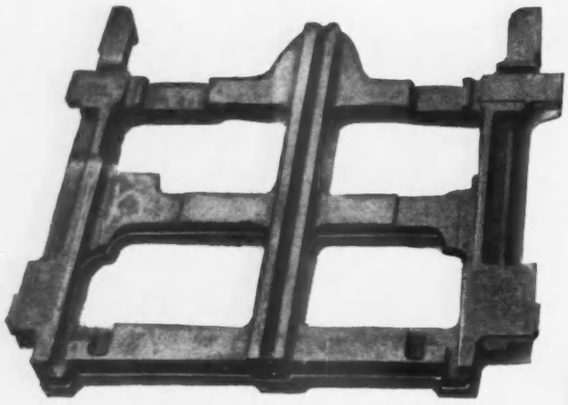
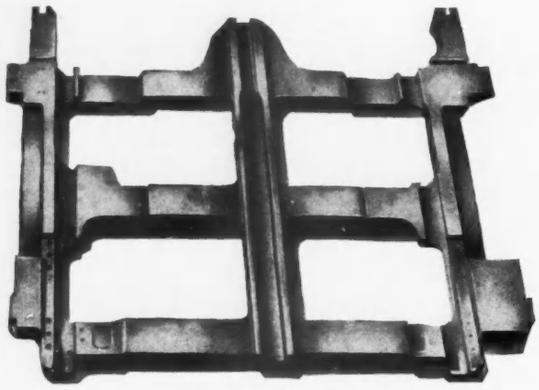
TG2 RM6 A

cast . .



Overall dimensions approximately

30 inches square



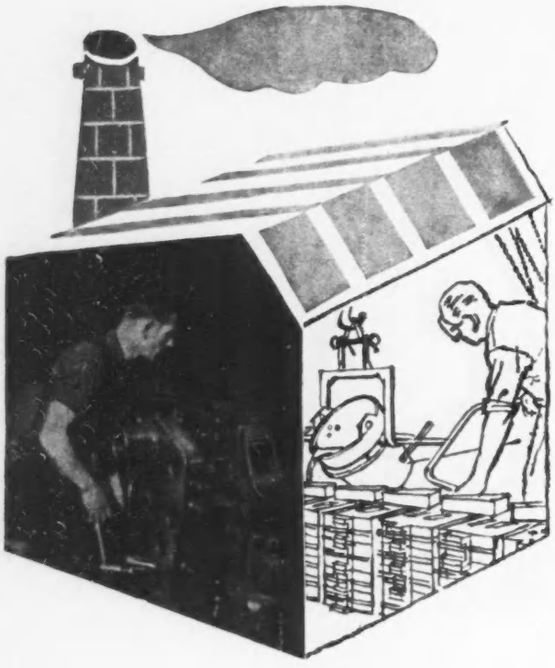
Machined tolerances to ± .002 inches

on parts shown

. . . and machined . .

47 machining operations

under one roof



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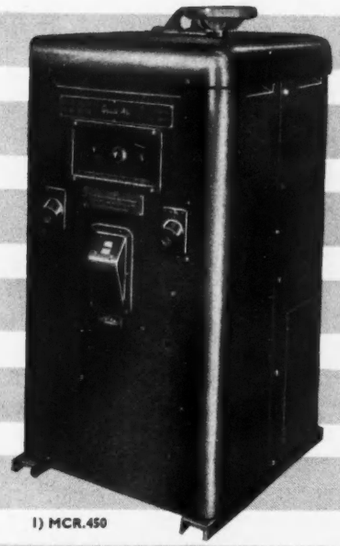
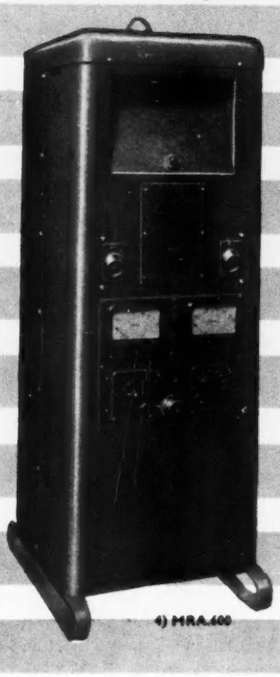


1) MCR.450

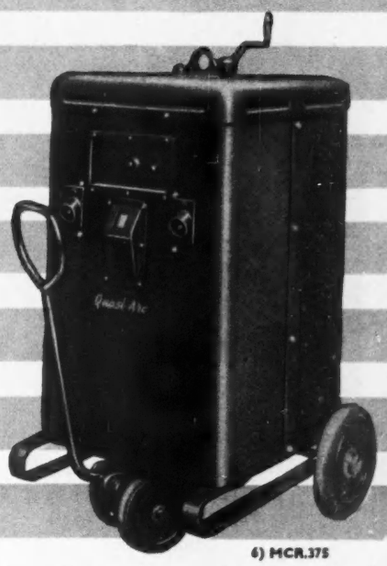
2) MR.375

3) MRS.425



4) MRA.600

5) MRA.1200



6) MCR.375

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2. 25-375 amps, with infinitely variable remote current control for manual welding.
3. 85-425 amps, with remote current control, specially designed for use with the SIGMA process.
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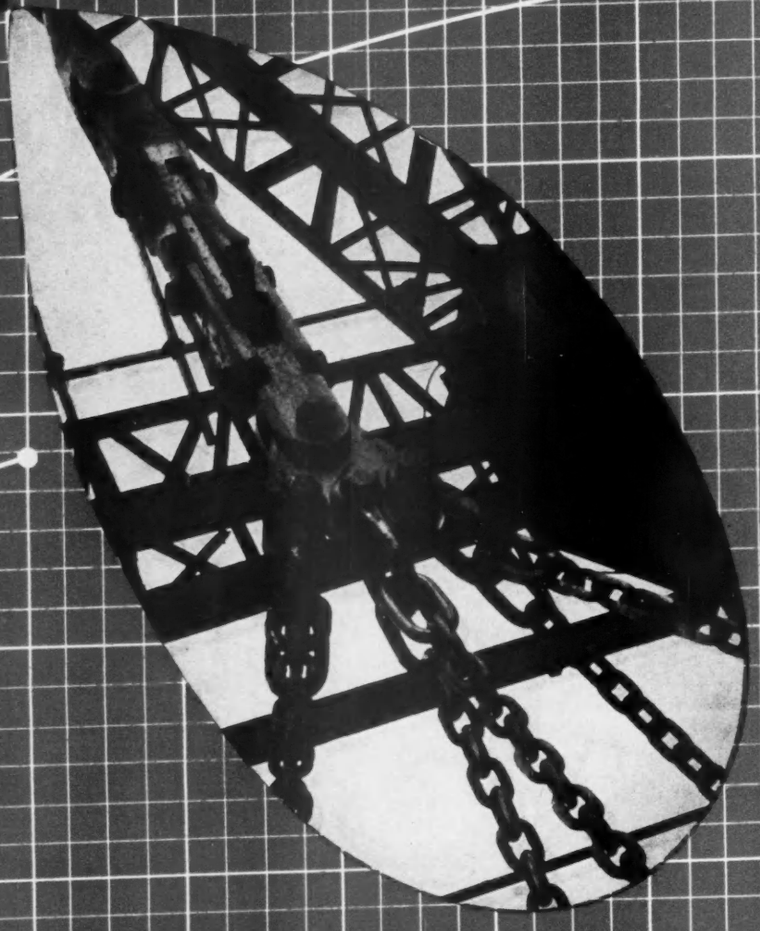
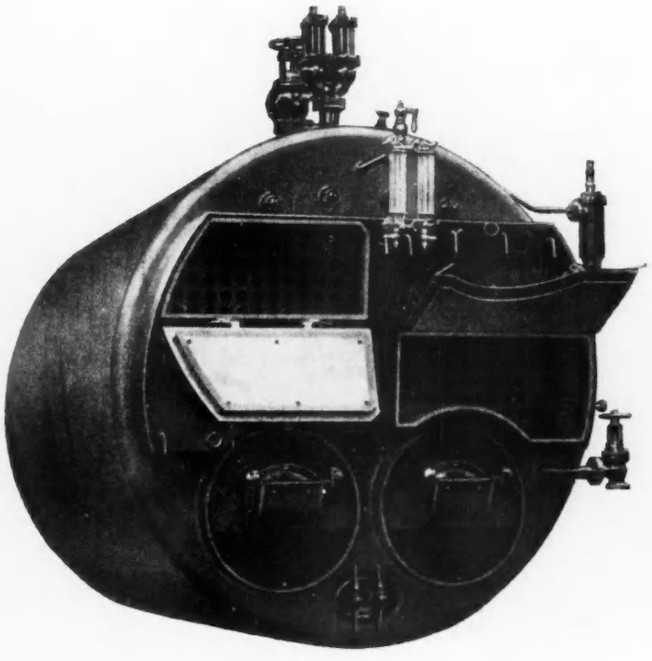
PHOTO SHOWS 20 TON GEAR AT A LANCASHIRE COLLIERY

Parsons chains



Parsons CHAIN COMPANY LTD STOURPORT-ON-SEVERN WORCS TEL: STOURPORT 2551

RIGHT ON THE MAP



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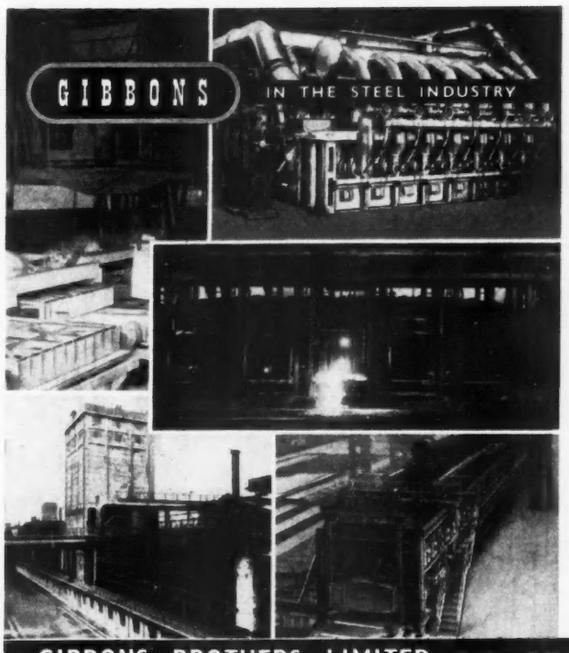

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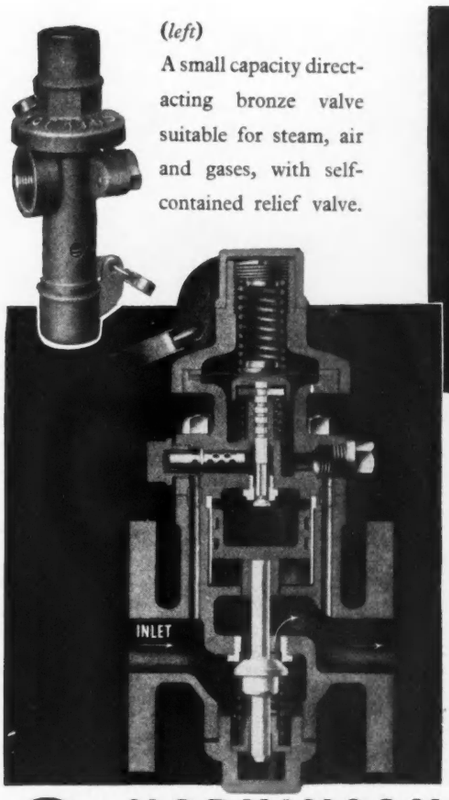
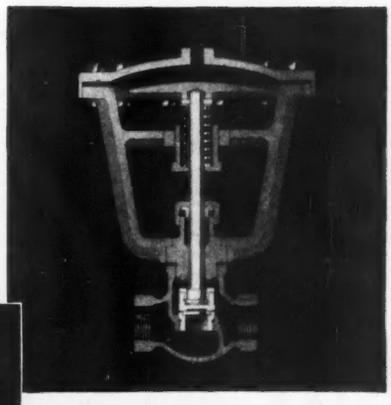


(left)
A small capacity direct-acting bronze valve suitable for steam, air and gases, with self-contained relief valve.



(above)
'D' Type Direct-acting Diaphragm Reducing Valve in bronze, for inlet pressures up to 100 lb. and reduced pressures below 15 lb. Suitable for canteen kitchens, hospitals, etc.

(left)
'R' Type Reducing Valve, full area, relay-operated, suitable for any pressure reduction subject to at least 15 lb. between inlet and outlet. Sizes ¼" to 3" bore inclusive.

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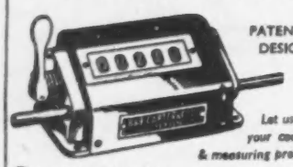

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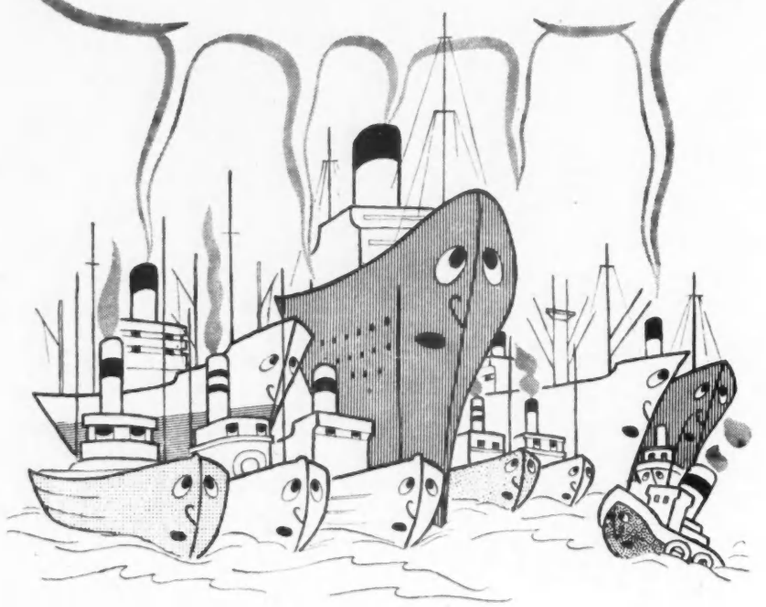

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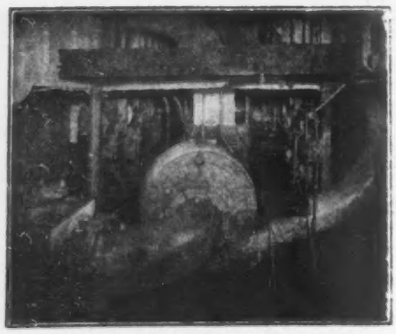

Main Machinery Room showing High Efficiency Pump in foreground, with quick release bean for rapid inspection of pump.

All Electric Reclamation Pumping Plant "Larubi" Constructed for the Anglo-Iranian Oil Co. Ltd. Dimensions: 74 × 22 × 7 feet. Pumping capacity: 200 tons of mud per hour through 500 feet of shore pipe to a height of 30 feet above low water.

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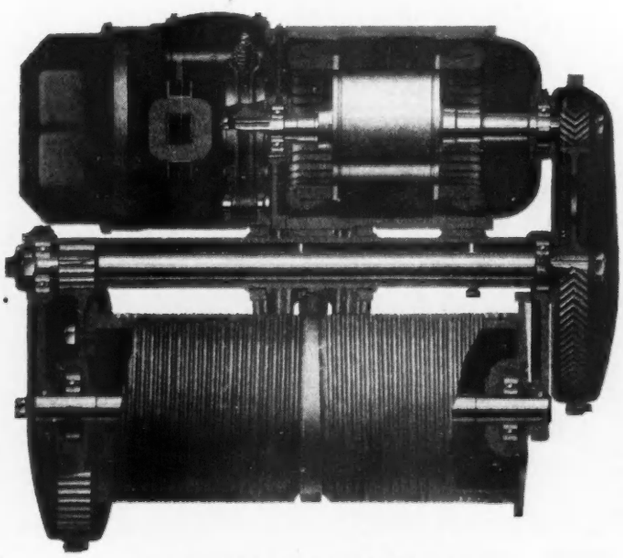

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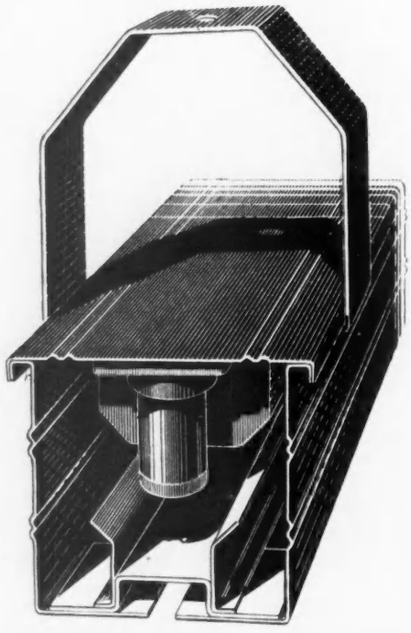
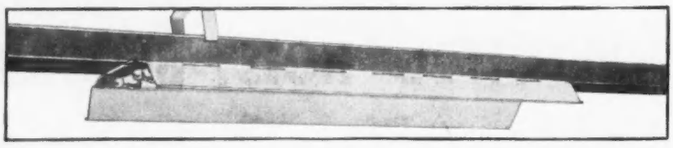


This is a detailed cross-section of the trunking showing the separate channels for telephone and power cables.



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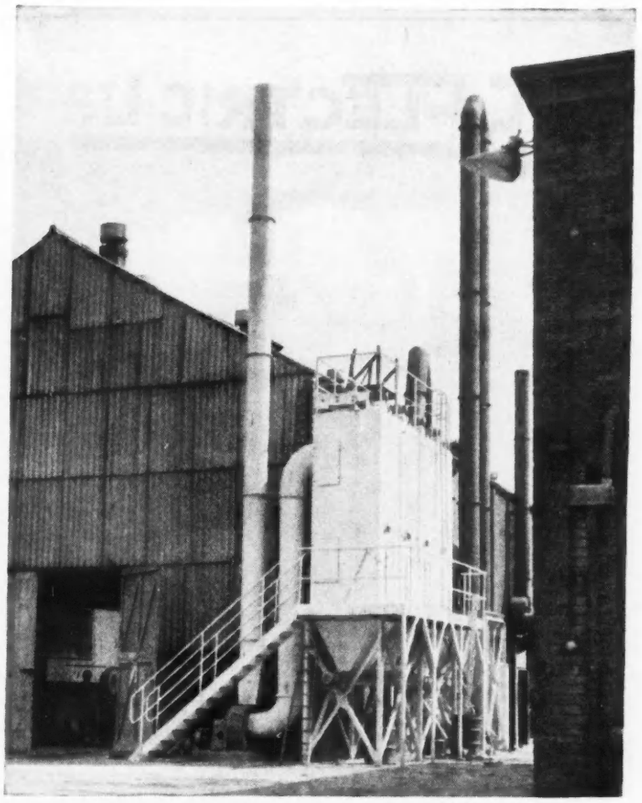

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The fully automatic Filter Plant, here shown in operation, was installed by Pontifex for British Lead Mills Ltd., at Welwyn Garden City, to clean the gases from an oil-fired rotary furnace treating non-ferrous metals. It was completed, and working, three weeks ahead of scheduled delivery date. The absence of visible discharge from the exhaust stack should be noted.

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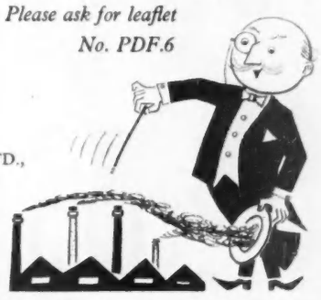

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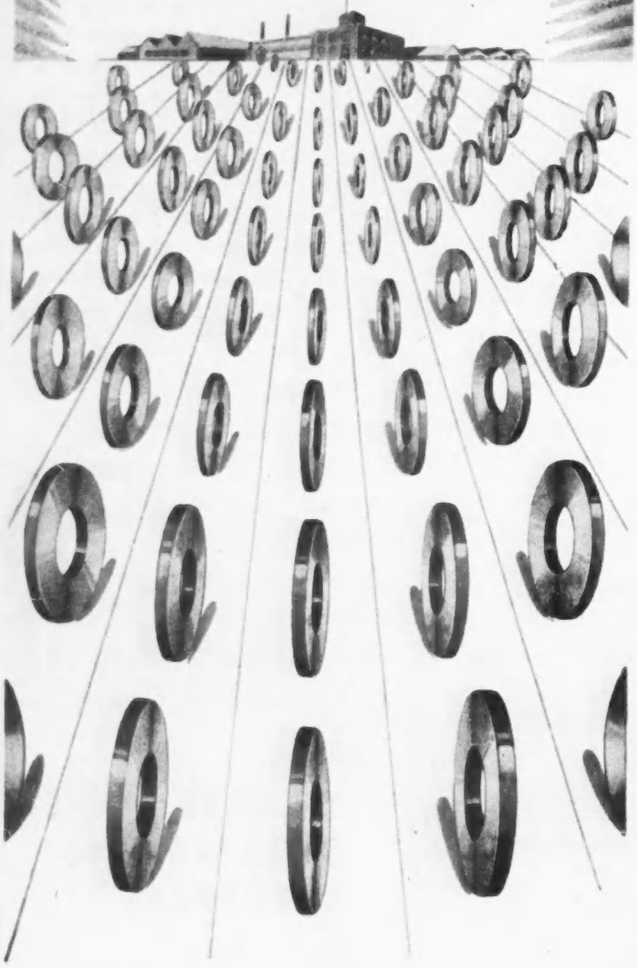

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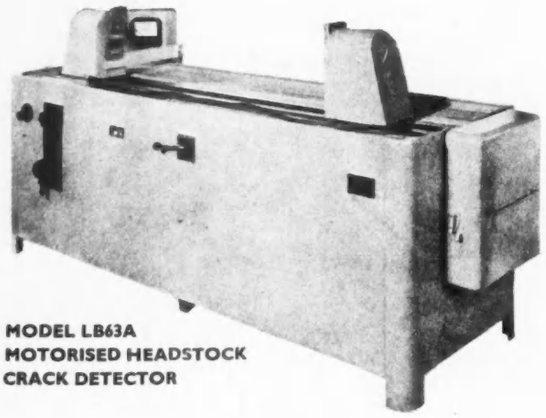

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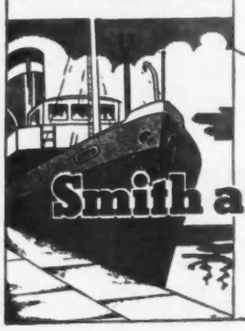

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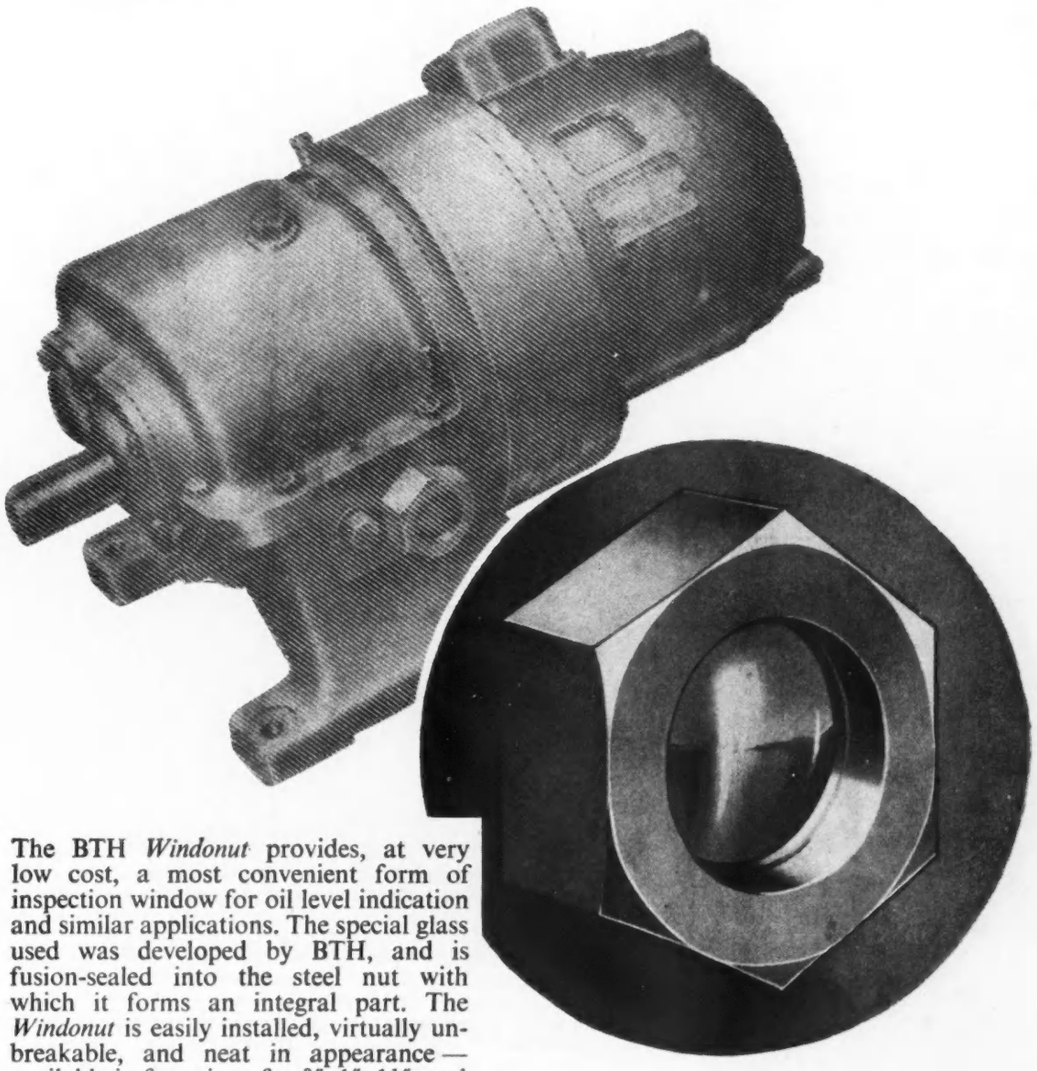

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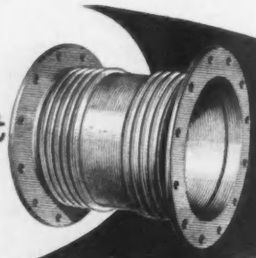
Let's get  together with . . .

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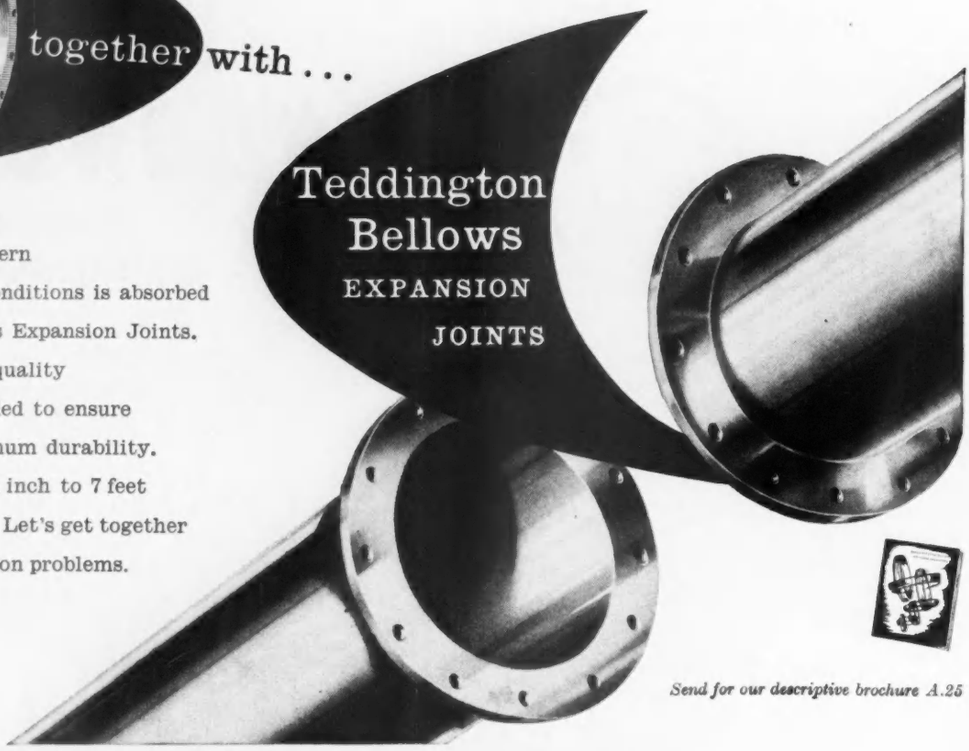

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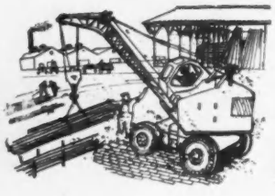

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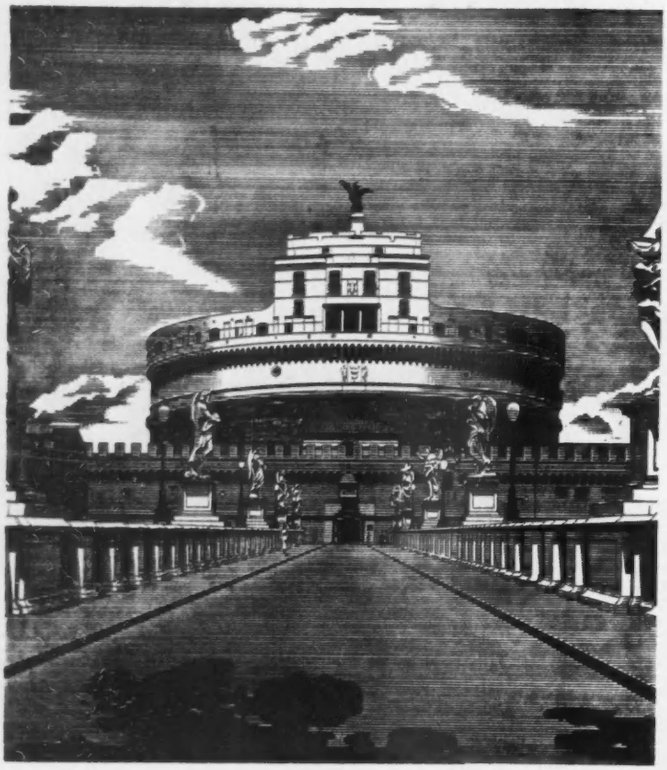

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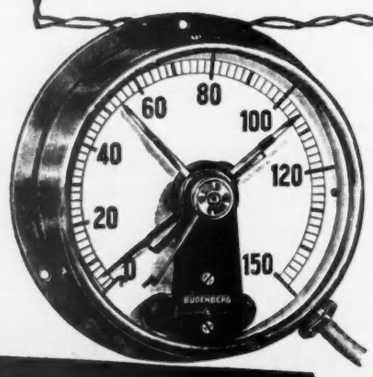

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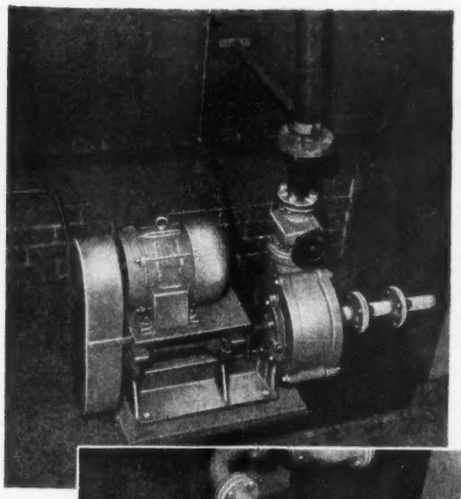

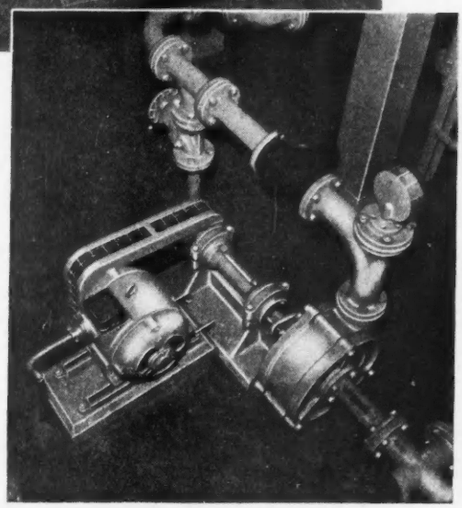

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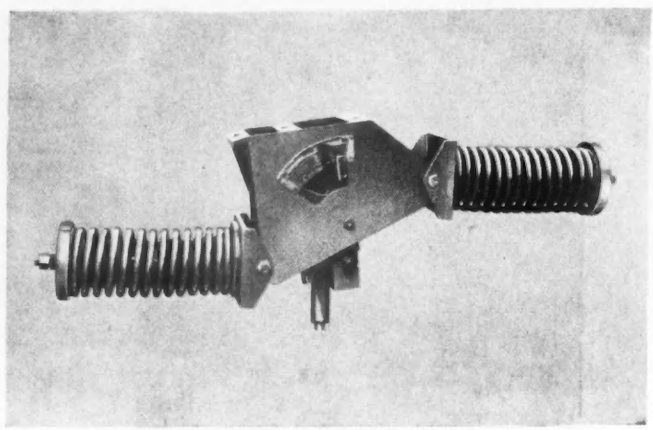

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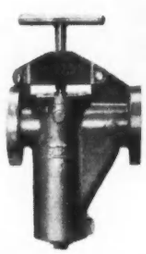

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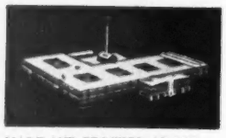

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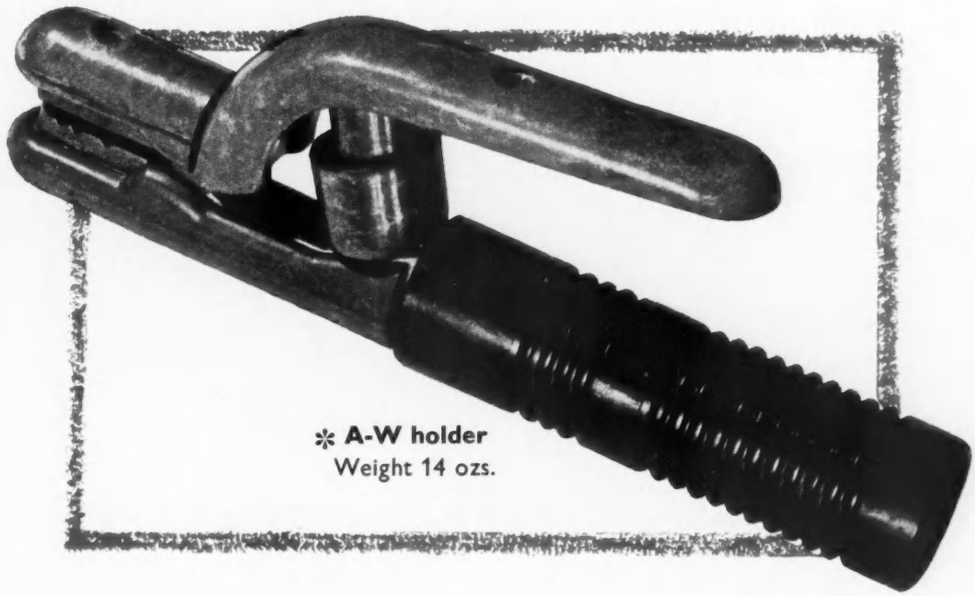

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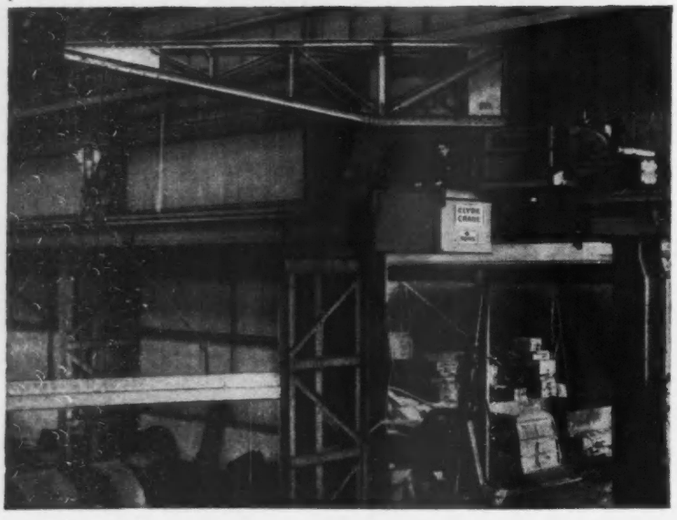

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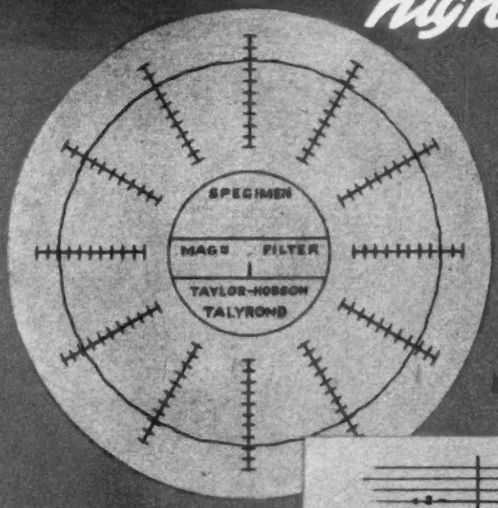

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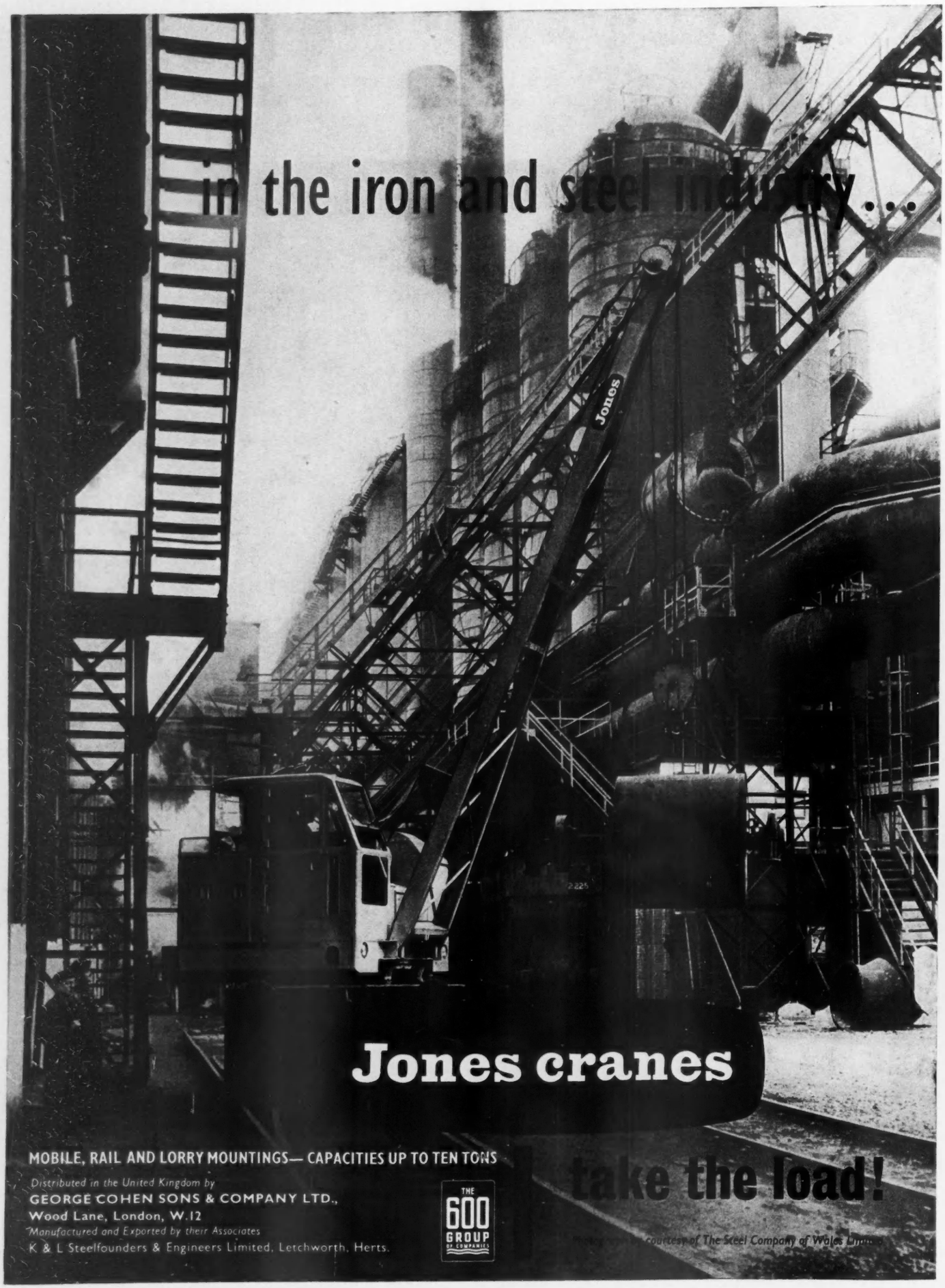
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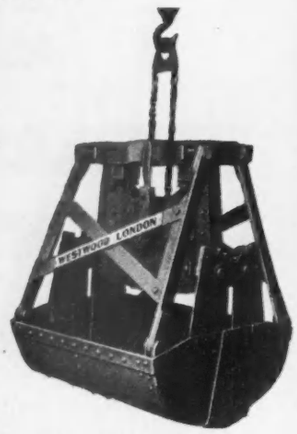

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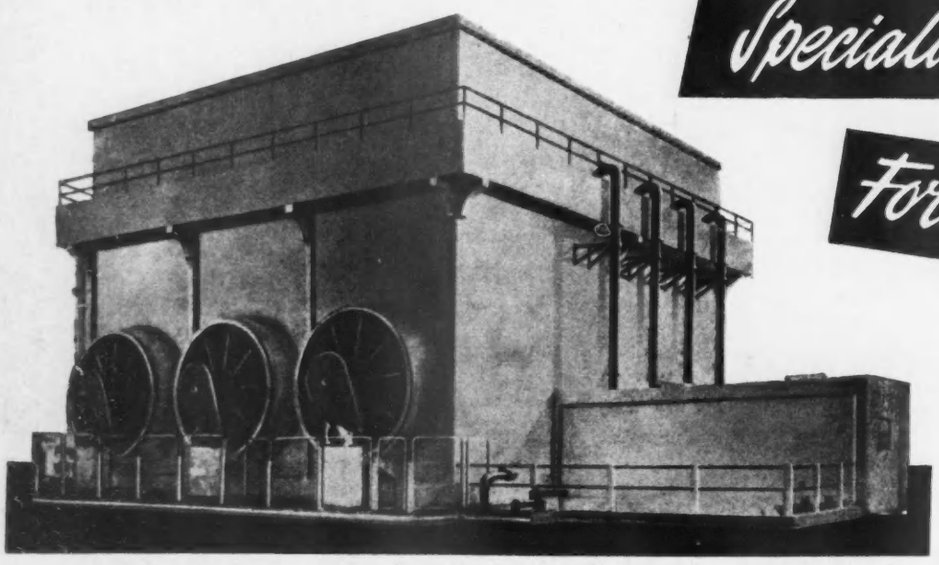

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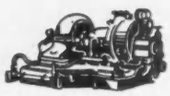

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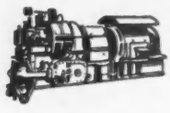

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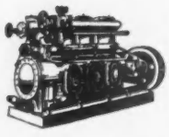

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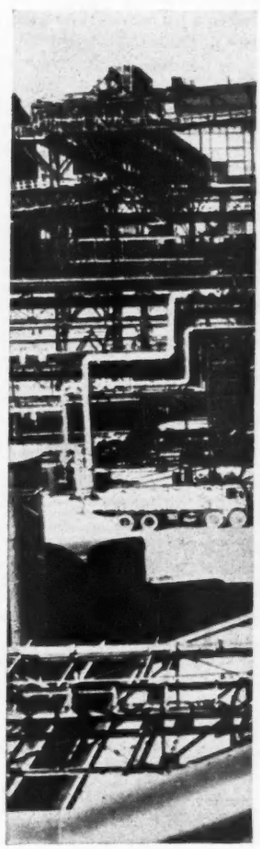
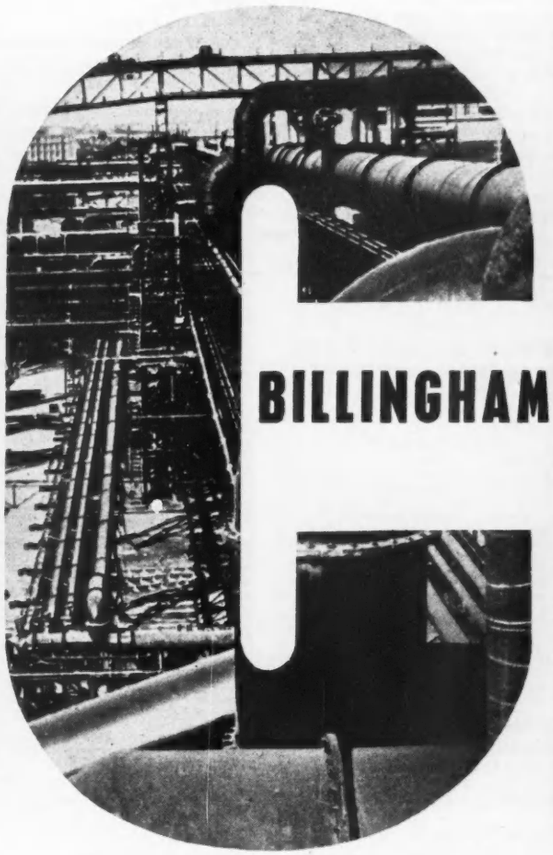
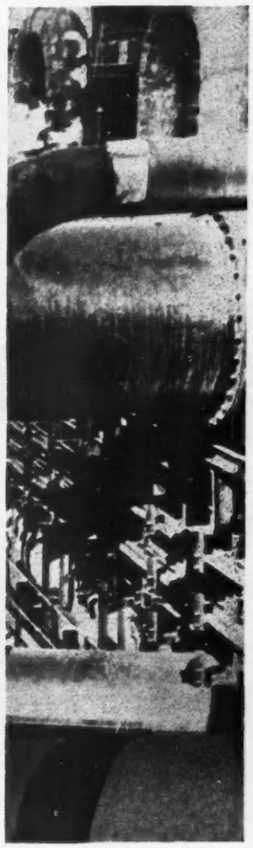
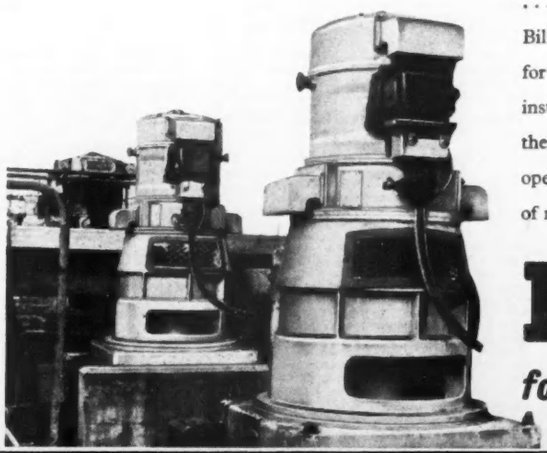






come wind, come weather



. . . Leaders in open air pump installations, I.C.I. at their Billingham Works employ Harland Electroglide Pumps, for water cooling duties; some twenty having been installed. Defying, in addition to the vagaries of climate, the corrosive effects of salt-laden sea air, these electrically operated pumps continue to give service with the minimum of maintenance.

HARLAND

for DEPENDABLE PUMPING PLANT

THE HARLAND ENGINEERING CO. LTD., ALLOA, SCOTLAND

LONDON & EXPORT SALES OFFICES HARLAND HOUSE 20 PARK STREET W.1

Branches in Bristol Glasgow Leeds Newcastle Nottingham Timperley (Cheshire) Wolverhampton & Overseas

P4142. A140/4

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, *e.g.*, ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, *e.g.*, ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/-, which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*— Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

UNIVERSITY OF EDINBURGH AND HERIOT-WATT COLLEGE

JOINT DEPARTMENT OF CHEMICAL TECHNOLOGY AND CHEMICAL ENGINEERING

APPOINTMENT

Applications are invited for either a LECTURESHIP or an ASSISTANTSHIP.

Lectureship : the initial salary will be at a point on the scale £900 to £1650 per annum, according to qualifications and experience. It is hoped to appoint a man who will be active in some field of chemical engineering research of his own choice.

Assistantship : the initial salary will be in the range £700 to £850 per annum. Teaching duties will not be heavy and the Assistant may engage in research for a Ph.D.

Both posts are subject to superannuation, and family allowance will be payable where applicable.

The successful applicant will be expected to take up duty on 1st October, 1958.

Applications will be considered from chemical engineers, physicists, chemists or mechanical engineers, or from mathematicians who have experience in applied science.

Further particulars may be obtained from the undersigned, with whom applications (four copies), giving the names of two referees, should be lodged not later than 24th March, 1958. (A candidate from overseas may submit one copy of this application.)

CHARLES H. STEWART,
Secretary to the University.

January, 1958. E6058

UNIVERSITY OF KHARTOUM

LECTURESHIP

Applications are invited for (a) SENIOR LECTURESHIP or (b) LECTURESHIP in Civil Engineering.

Salary scales : (a) £S1602 by £S75 to £S1977 p.a.; (b) £S1152 by £S75 to £S1677 p.a., entry point according to qualifications and experience. Cost-of-living allowance approximately £S100 p.a., outfit allowance £S50. Family allowances : wife, £S60 p.a.; first child, £S90 p.a. ; second and third child, £S30 p.a. each. (£S1 = £1 0s. 6d. sterling.) Passages for appointee and family on appointment, termination and annual leave. Appointment on contract for 3 years. Superannuation scheme.

Detailed applications (8 copies), naming 3 referees, by 15th April, 1958 to Secretary, Inter-University Council for Higher Education Overseas, 29, Woburn Square, London, W.C.1, from whom further particulars may be obtained. E6104

MINISTRY OF EDUCATION

H.M. INSPECTORS (MEN AND WOMEN)

Ministry of Education requires, for England only, H.M. INSPECTORS (MEN AND WOMEN), preferably under 50. Good educational qualifications and teaching and practical experience in Architecture, Building, Applied Chemistry, Applied Physics, Engineering (Mechanical, Civil and Electrical), or Commerce.

Permanent posts, non-contributory pension. Salary : London (men), £1525 (11 increments) to £2250 ; elsewhere slightly less. Appointments may be made above minimum. Higher posts filled by promotion ; also some with £140 allowance.

Application form from Secretary (Inspectors' Section), Ministry of Education, Curzon Street, London, W.1.

Closing date 3rd April, 1958. E6122

UNIVERSITY OF KHARTOUM

LECTURESHIP

Applications are invited for (a) SENIOR LECTURESHIP, or (b) LECTURESHIP in (1) Engineering Mathematics, and (2) Mechanical Engineering.

Salary scales (a) £S1602 by £S75 to £S1977 p.a.; (b) £S1152 by £S75 to £S1677 p.a., entry point according to qualifications and experience. Cost-of-living allowance approximately £S100 p.a., outfit allowance £S50. Family allowances : wife, £S60 p.a.; first child, £S90 p.a.; second and third child, £S30 p.a. each. (£S1 = £1 0s. 6d. sterling.) Passages for appointees and family on appointment, termination and annual leave. Appointments on contract for 5 years. Superannuation scheme.

Detailed applications (8 copies), naming 3 referees, by 15th April, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29, Woburn Square, London, W.C.1, from whom further particulars may be obtained. E6105

PUBLIC APPOINTMENTS

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY
LONDON, E.C.1

GRADUATE RESEARCH APPRENTICESHIPS

Applications are invited for TWO GRADUATE RESEARCH APPRENTICESHIPS awarded by the Glacier Metal Company, Ltd., value between £540–£700 p.a., depending on age ; tenable for two years in the Department of Civil and Mechanical Engineering from September, 1958, or earlier. Applicants should have an Honours Degree in Engineering, but applications from students graduating in June, 1958, will be considered. The successful candidates will be expected to register for a Higher Degree of the University of London.

The research projects are concerned with the lubrication of journal bearings and the mechanical properties of bearing metals.

Further particulars may be obtained from the Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1. E6119

DARENTH AND STONE HOSPITAL MANAGEMENT COMMITTEE
NEAR DARTFORD, KENT

SUPERINTENDENT ENGINEER

Applications are invited for the post of SUPERINTENDENT ENGINEER at the above Group, which consists of a hospital for mental defectives of 2010 beds ; a mental hospital of 635 beds, and a Polish Neurosis Unit of 180 beds. The hospitals are situated within 3 miles of each other. A house is available on the hospital estate.

Salary and conditions of service in accordance with the recommendations of the National Whitley Council (£1105 by £30 (2) by £40 (1) by £45 (2) to £1295 per annum).

Applicants should have extensive practical experience of the operation, maintenance and co-ordination, including both mechanical and electrical, of hospital engineering services, and should hold an engineering qualification at least up to the standard approved by the Ministry of Health.

Applications, together with full details of qualifications and experience, and the names of three referees, to the Group Secretary, Stone House, near Dartford Kent, within fourteen days of the appearance of this advertisement. E6080

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION

ATOMIC ENERGY SECTION

The British Shipbuilding Research Association has a vacancy in its Atomic Energy Section for a man aged about 25, with a good University Degree in Marine or Mechanical Engineering and with practical training and experience. Research experience an advantage. The person appointed will be required, in the first instance, to work in the Association's team at the Atomic Energy Research Establishment, Harwell, studying the possible application of nuclear power to merchant ship propulsion. Experience of nuclear energy is not an essential qualification as training in this will be given. The commencing salary will depend upon age and qualifications, and the appointment is subject to the Federated Superannuation System for Universities.

Applications, with full particulars, should be addressed to B.S.R.A., 5, Chesterfield Gardens, Curzon Street, London, W.1. E6093

A.E.R.E., HARWELL

ENGINEERING CALCULATIONS

QUALIFIED ENGINEERS

QUALIFIED ENGINEERS required to join team engaged on design of low-energy reactors and "in-pile" experiments. Calculations of heating and reactivity effects, nuclear shielding heat transfer and stress. Honours Degree in Engineering advantageous.

Salary from £815 (age 25) to £1740, according to age, qualifications and experience.

Send post card to Group Recruitment Officer (1040Y/25), A.E.R.E., Harwell, Didcot, Berks, for application form and details. E6095

PUBLIC APPOINTMENTS

SHEFFIELD CORPORATION WATERWORKS

APPOINTMENTS

Applications are invited from experienced Civil Engineers for the following appointments on the staff of the Sheffield Water Undertaking, for the design and construction of important waterworks.

TWO CHIEF ASSISTANTS IN CHARGE OF SUB-SECTIONS. Candidates must be Corporate Members of the Institution of Civil Engineers, and possession of a University Degree in Civil Engineering will be considered an advantage. Salary, Grade A_2 £1205 by £60 (2) by £55 to £1380. They should have had experience in the design and construction of large civil engineering works, including one or more of the following :—Industrial buildings and plant erection, tunnelling, bridges, reinforced and mass concrete, service reservoirs, piling, pipelines, aqueducts or sewers.

TWO SENIOR ENGINEERING ASSISTANTS. Candidates should hold A.M.I.C.E., A.M.I.Mun.E., or University Degree, or equivalent qualification. Salary Grade A.P.T. V, £1175 by £50 to £1325. Candidates' experience should be similar to that of the Chief Assistants, but less extensive.

TWO SENIOR ENGINEERING ASSISTANTS. Candidates should hold A.M.I.C.E., A.M.I.Mun.E., or University Degree, or equivalent qualification. Salary Grade A.P.T. IV, £1025 by £50 to £1175. Candidates must be sufficiently experienced to work on their own when required.

ONE ENGINEERING ASSISTANT. Candidates should have passed Parts A and B of the examination of the Institution of Civil Engineers, or hold a University Degree, or have equivalent qualifications. Salary Grade, Special Classes, £750 by £40 to £1030. They should have two years' practical experience in a junior capacity.

For all the above appointments commencing salary will be in accordance with age, qualifications and experience. The appointments are governed by the provisions of the Local Government Superannuation Acts, and the successful candidates will be required to pass a medical examination.

Applications, stating age, qualifications, present and past appointments (with dates and salaries) and experience, quoting the names of not more than three persons to whom reference can be made, should reach the undersigned not later than the 25th February, 1958.

JOHN HEYS,
Town Clerk.

Town Hall,
Sheffield, 1. E6089

AIR MINISTRY WORKS DESIGN BRANCH

LONDON

DESIGNER DRAUGHTSMEN

Air Ministry Works Design Branch require in London DESIGNER DRAUGHTSMEN for Bulk Petroleum Storage and Pumping Installations, experienced in one or more of the following : (a) storage tank layout and design ; (b) pump house and plant layout ; (c) development of pipe line schemes ; (d) hydraulic calculations. Technical training to O.N.C. standard required.

Salaries up to £1015 per annum. Starting pay dependent on age, qualifications and experience. Long term possibilities with pensionable and promotion prospects. 5-day week, 3 weeks' 3 days' leave a year. Normally natural born British subjects.

Write, stating age, qualifications, employment details, including type of work done, to any Employment Exchange, quoting Order No. Borough 105. E5049

SHEFFIELD REGIONAL HOSPITAL BOARD

APPOINTMENT OF PRINCIPAL ASSISTANT ENGINEER

Applications are invited for the appointment of PRINCIPAL ASSISTANT ENGINEER in the Board's Engineering Department. Salary £1150–£1350. Applicants must hold Corporate Membership of the Institution of Mechanical Engineers and must have experience in the design of engineering services for hospitals or for large public buildings.—Applications, in writing, with particulars of age, present and past appointments, and the names of three referees, to be addressed to Secretary to the Board, Fulwood House, Old Fulwood Road, Sheffield, 10, not later than 24th February, 1958. E6128

PUBLIC APPOINTMENTS

WELSH REGIONAL HOSPITAL BOARD

ASSISTANT ENGINEER (MECHANICAL)

Applications are invited for an ASSISTANT ENGINEER (MECHANICAL). Applicants must have had a sound technical training in mechanical engineering and experience in the preparation of estimates, specifications and drawings for steam boiler plant, central heating, hot water supply and ventilating systems. The minimum qualification required is Graduate Membership of the Institution of Civil Engineers or the Institution of Mechanical Engineers, having passed the qualifying examinations for those grades, or a Graduate Membership of the Institution of Heating and Ventilating Engineers, having passed the Associate Membership examination of that Institution.

The salary scale will be £700 by £25 (3) by £30 (1) by £35 (6) to £1015, and the point of entry will depend upon the relative practical experience approved by the Board. The appointment is superannuable and terminable by one month's notice on either side.

Applications, stating age, experience, qualifications and present position, together with the names and addresses of two referees, should be addressed to the Secretary, Welsh Regional Hospital Board, Temple of Peace and Health, Cardiff, within 10 days of this advertisement appearing. E6115

ASSISTANT ENGINEER (CIVIL)

LONDON OFFICE

ASSISTANT ENGINEER (CIVIL) required for their London office by the Crown Agents for Oversea Governments and Administrations for appointment to pensionable establishment on probation for 2 years. Commencing salary between £595 p.a. at age 21, £805 at age 25, and £1085 at age 34 or over, in scale rising to £1250. Prospects of promotion. Fully qualified officers at least 27 years of age may be eligible for special increase of £75 after 2 years' service. Liberal leave, five-day week. Candidates must be Corporate members of the Institution of Civil Engineers or the Institution of Structural Engineers, or, if below the age of 28, must have passed Parts 1 and 2 of the Associate Membership examination of the Institution of Civil Engineers or hold an exempting degree, or have passed the Associate Membership examination of the Institution of Structural Engineers. They must be good draughtsmen and have had experience in the design of bridges in steel or reinforced concrete, and should have served in the drawing-office of a structural firm, Railway Company or Consulting Engineers. Site experience an advantage. Candidates should be prepared to spend short periods on site surveys overseas, in which event special overseas allowances are payable. —Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2A/42637/EH. E6120

CENTRAL ELECTRICITY GENERATING BOARD

NORTH EASTERN DIVISION

STEAM TESTING DEPARTMENT

SECOND ASSISTANT ENGINEER

Applications are invited for the appointment of a SECOND ASSISTANT ENGINEER in the Steam Testing Department, with Headquarters at Dunston, to control a small section investigating the thermal performance and operating characteristics of a wide variety of modern steam plant.

The work calls for considerable initiative and offers experience of testing techniques in an interesting field. A knowledge of power station operation will be considered an advantage.

Applicants should be Corporate Members of the Institution of Mechanical or Electrical Engineers and should have previous plant testing experience.

The salary for the appointment will be in accordance with the National Joint Board Agreement, Schedule "B," Grade 4 (£1145–£1375), and will commence at a point commensurate with qualifications and experience.

Forms of application may be obtained from Divisional Establishments Officer, Central Electricity Generating Board, North Eastern Division, Carliol House, Newcastle upon Tyne, to whom they should be returned to arrive not later than 3rd March, 1958 E6081

PUBLIC APPOINTMENTS

GHANA HOUSING CORPORATION

ACCRA

CIVIL ENGINEERS

Applications are invited from qualified candidates for appointment as CIVIL ENGINEERS in the Ghana Housing Corporation, with head office at Accra.

The work will consist of designing of roads, sewers, surface water drains and sewage disposal plants for new and existing housing estates and supervision of construction and maintenance of works under construction.

The appointment in the case of locally recruited Ghanaian candidates may be permanent. The appointment in the case of overseas candidates are for 2 tours of duty, 15–18 months' duration. In both cases the salary scales will be £1120 by £50 to £1530 ; £1600 by £60 to £2020, depending on age, qualifications, experience and place of birth. Locally recruited Ghanaian candidates will be required to contribute to the Corporation's provident fund's scheme, which is 7½ per cent of employees' contribution and 17½ per cent employers' contribution. Overseas candidates will receive overseas allowance of £350 per annum and a gratuity of £12 10s. for each completed month of service at the end of contract. (Free medical and dental treatment will be provided for the officer, his wife and family.) For overseas candidates free first-class passages will be provided for the officer, his wife and up to three children under the age of 18 years, once each way during a tour of duty. Earned leave and other conditions of service will be similar to those of Government employees.

The successful candidate will normally be stationed in head office, Accra, but will be called upon to travel to any area of Ghana where any development is in progress.

Candidates should either be Associate Members of the Institution of Civil Engineers or of the Institution of Municipal Engineers or possess a recognised Engineering Degree. Actual practical site experience and the knowledge of men and ability to co-operate on team basis with professional associations and indigenous contractors will be an advantage.

Apply, stating age, qualifications and experience, to the Director of Recruitment, Ghana High Commissioner's Office, 13, Belgrave Square, London, S.W.1. E6121

MANCHESTER CORPORATION WATERWORKS

ASSISTANT ENGINEERS

Applications are invited for the undermentioned engineering appointments on the temporary staff of the Corporation in connection with the design and execution of works included in (a) the Third and Fourth Instalments of the Haweswater Scheme, including the laying of 54in dia. steel pipes, and the construction of two service reservoirs (200 million gallons capacity) near Bury, Lancs, and (b) the filtration and treatment of the Longoendale supply.

ASSISTANT ENGINEERS (Class II). Salary in the range of £750/£1030 p.a., according to qualifications and experience.

Housing accommodation at a reasonable rental will be provided in certain cases.

Applications, stating (1) age, (2) education and training, (3) professional qualifications, (4) experience in the preparation of plans and construction of water works or other civil engineering works, together with the names of two referees, should be addressed to the Engineer and Manager, Waterworks Offices, Town Hall, Manchester, 2, so as to be received by the 21st February, 1958. E6051

THE REPUBLIC OF THE SUDAN

THE MINISTRY OF AGRICULTURE

AGRICULTURAL ENGINEERS

The Ministry of Agriculture has vacancies for TWO AGRICULTURAL ENGINEERS.

Candidates must possess a B.Sc. or its equivalent and have had good practical experience in the operation and management of mechanised farming equipment and experience in the training of operators. Age 23 to 45. Candidates must be fully literate in either English or Arabic.

Appointment will be on a short-term contract, with or without bonus, for a period of three years. Starting rate of pay will be determined according to age, qualifications and experience, in the salary range £S.1075 to £S.1675, with bonus, or £S.1146 to £S.1786 without bonus. A cost-of-living allowance, which is reviewed every two months, is payable and an outfit allowance of £S.50 on appointment. (£S.1 = £1 0s. 6d. sterling.) Annual leave with free air passage is granted. There is no income tax in the Sudan at present.

Write for further particulars and application forms to Sudan Embassy, Personnel Section, Cleveland Row, St. James's, S.W.1, quoting reference Agricultural Engineer 4/405. Closing date 31st March, 1958. E6136

LONDON TRANSPORT

CIVIL ENGINEER

London Transport require CIVIL ENGINEER, preferably between ages 35 and 50, with wide experience, both in design and carrying out of heavy engineering works (i.e. earthworks, drainage, bridging, retaining walls, heavy foundations, reinforced concrete and tunnelling) ; experience in general railway construction advantageous.

Candidates should be Chartered Civil Engineers, fully capable of organising and directing a section of the drawing-office in preparation of schemes, estimates, design, contract drawings, bills of quantities and specifications, and should have kept themselves abreast of modern design techniques.

Salary range : £1210 to £1420. Medical examination, free travel.—Applications within 7 days to Staff and Welfare Officer (F/EV), London Transport, 55, Broadway, S.W.1. E6094

PUBLIC APPOINTMENTS

PLANT ENGINEERS

are required by the

UNITED KINGDOM ATOMIC ENERGY AUTHORITY INDUSTRIAL GROUP

at

CAPENHURST WORKS, CHESTER, AND SPRINGFIELDS WORKS, PRESTON

Opportunities exist for men under 27 years of age, who have recently qualified as Mechanical or Electrical Engineers, to acquire knowledge and managerial experience in a new and expanding industry.

Successful applicants will be given training designed to fit them to take managerial responsibility about one year after entry. During this period they will assist in the Operation and/or Maintenance of the Works and will receive guidance in management techniques, by lectures, discussions and visits to other departments.

Applicants must have a University Degree in Mechanical or Electrical Engineering or equivalent qualifications. It is desirable that they should also have served a recognised apprenticeship, though consideration will be given to applicants who have received good practical training on a less formal basis.

An attractive salary, assessed according to age, qualifications and experience, will be paid during the training period.

Contributory pension scheme.

Housing or assistance towards legal expenses on house purchase may be available.

Send postcard for application form, quoting reference 2246, to :

Recruitment Officer,
U.K.A.E.A.,
I.G.H.Q., Risley, Warrington, Lancashire.

Closing date : 24th February, 1958. E6073

CENTRAL ELECTRICITY GENERATING BOARD

PRODUCTION, INSPECTION AND TEST SUB-BRANCH

SECOND AND THIRD ASSISTANT ENGINEERS (MECHANICAL AND ELECTRICAL)

Central Electricity Generating Board require SECOND AND THIRD ASSISTANT ENGINEERS (MECHANICAL AND ELECTRICAL) in the Production, Inspection and Test Sub-Branch. The Sub-Branch of the Chief Engineer's Department is concerned with the production, inspection and test in manufacturers' works of mechanical and electrical plant and equipment required for generation (including nuclear) and transmission purposes. The selected candidates will be based at any one of the Regional Offices which are situated in London, Birmingham, Derby, Manchester, Leeds, Newcastle and Glasgow.

Candidates for Second Assistant Engineer should preferably be Associate Members of the Institutions of Mechanical or Electrical Engineers, and for Third Assistant Engineer have qualifications equivalent to Graduate Membership of such Institutions. Recent experience of production, inspection and test of mechanical or electrical plant in manufacturers' works is essential.

Salaries : Second Assistant Engineer, £1160–£1510 ; Third Assistant Engineer, £1055–£1265.

Applications, stating age, qualifications, experience, present positions and salary, to I. G. Ellis, Personnel Officer, 24/30, Holborn, London, E.C.1, by 27th February. Envelopes should be marked "Confidential," quoting reference ENR/41. E6113

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY GENERATING BOARD

ELECTRONIC DIGITAL COMPUTING STAFF—SYSTEM PLANNING BRANCH

Applications are invited for the following appointments for the electronic digital computing service within the System Planning Branch of the Chief Engineer's Department, Headquarters, Bankside House, London, S.E.1.

COMPUTER ENGINEER (ENR/45)

To take charge of the day-to-day working of the Computing Section. The post calls for ability to discuss computer applications with engineers and other potential users in the electricity supply industry and to expose the essentials of a problem to programming staff. For this reason, experience of the electricity supply industry and a sound knowledge of digital computing techniques is essential. Corporate Membership of the Institution of Electrical Engineers or equivalent qualifications would be considered an advantage.

Salary £1435–£1795 per annum.

ANALYTICAL AND STATISTICAL MATHEMATICIANS (ENR/46)

This Section will provide a consultant service to the computer programming staff and carry out statistical and analytical investigations into problems associated with long-term forecasts, including the growth of electricity demand and the related requirements in terms of new generating and transmission plant to provide for the optimum growth of the system as a whole. A high degree of mathematical ability is required and applicants should possess a good Degree in Mathematics or Statistics with subsequent experience in industry. The successful applicant for the senior post (Grade 1) will be expected to co-ordinate the work of the Section and carry out mathematical research and to develop new techniques for dealing with system planning problems.

Salaries : Grade 1, £1435–£1795 per annum ; Grade 2, £1210–£1570.

PROGRAMMERS (ENR/47)

To deal with the solution by digital computer of a variety of problems mainly associated with the electricity supply industry. Previous experience in numerical analysis and the use of electronic digital computers would be considered an advantage, but is not essential. Applicants should hold a University Degree in Mathematics or its equivalent and be interested in the study of engineering systems.

Salaries £1210–£1570 or £1105–£1315, according to qualifications and experience.

COMPUTER MAINTENANCE ENGINEERS (ENR/48)

To undertake the servicing and maintenance of electronic and other equipment associated with a digital computer establishment. Previous experience on computer maintenance is not essential and successful candidates will be required to undertake a course of instruction at the computer manufacturer's works. A knowledge of computer design or of pulse techniques, as applied to radar, would be considered an advantage. Applicants should possess qualifications leading to Graduate Membership of the Institution of Electrical Engineers.

Salaries £1105–£1315 or £870–£1045 per annum, according to qualifications and experience.

Applications, stating age, qualifications, experience, present position and salary, and also quoting specific vacancy number, should be forwarded under confidential cover to I. G. Ellis, Personnel Officer, 24/30, Holborn, London, E.C.1, by 26th February. E6114

STOKE-ON-TRENT HOSPITAL MANAGEMENT COMMITTEE

SUPERINTENDENT ENGINEER

Applications are invited for the new post of SUPERINTENDENT ENGINEER, to be responsible for the satisfactory operation, maintenance and co-ordination of the engineering services, mechanical and electrical, of the Stoke-on-Trent Group of Hospitals. Applicants must possess a Higher National Diploma or Certificate in Mechanical Engineering or the City and Guilds Full Technological Certificate in Plant Engineering or their equivalent. Officers in post are not debarred from applying by lack of a higher qualification.

Salary within the scale of £1105–£1295, with possible maximum of £1355.

Forms of application may be obtained from the Group Secretary, Stoke-on-Trent H.M.C., Princes Road, Stoke-on-Trent, to be returned not later than 28th February. E6133

SENIOR RUNWAY DESIGN ENGINEER

$9,060—$10,140

DEPARTMENT OF NATIONAL DEFENCE
R.C.A.F., OTTAWA, CANADA

TO

- Develop runway criteria and standards
- assess existing runways
- Design major rehabilitation projects
- Investigate new concepts of subgrade support
- Recommend new types of construction for development of heavy pavements
- Develop liaison internally and with outside agencies

Extensive experience in a related field is required.

For additional information and application forms write to the Canadian Department of Labour, 61 Green Street, London, W.1. Please quote Competition Number 58-1251.

E6106

PUBLIC APPOINTMENTS

SOUTH WEST SUBURBAN WATER COMPANY

ASSISTANT ENGINEER

Applications are invited for the above vacancy in the Chief Engineer's Department.

Candidates should have either an Engineering Degree or have passed Sections I and II of the Institution of Civil Engineer's examination. They should preferably have spent about two years in the water or civil engineering industries.

Duties will be assist in the day-to-day running of the undertaking and with the design and construction of a 3 m.g. reinforced concrete service reservoir. Other new works are contemplated. The company serves an area of approximately 100 square miles, with a population of 200,000.

The salary offered is £800 p.a., or slightly above, according to age and experience. The appointment, which is subject to medical examination, is permanent and pensionable.

Applications, stating age, qualifications and experience, should be sent to the Chief Engineer, South West Suburban Water Company, The Causeway, Staines, Middlesex, as soon as possible.

J. R. BROCK GRIGGS,
B.Sc., A.M.I.C.E., M.I.W.E.,
Chief Engineer.
E6092

THE REPUBLIC OF THE SUDAN

GINNING FACTORIES ENGINEER

The Sudan Gezira Board requires, for service in the Sudan, a GINNING FACTORIES ENGINEER.

Candidates must have served a recognised engineering apprenticeship, preferably with a firm, overhauling diesel engines, with subsequent experience in operating and overhauling diesels of 200 to 300 h.p., and also with hydraulic machinery and the types used in ginning factories for baling presses.

Terms of service : appointment will be on a short-term contract for a period of three years. A gratuity of one-fifth of total basic salary will be paid on satisfactory completion of service. Salary range : £S.1000 to £S. 1500. A cost-of-living allowance, which is reviewed quarterly, is payable and an initial outfit grant of £S.60. (£S.1 = £1 0s. 6d. Sterling.) Free accommodation is provided. Annual leave of 60 days is granted. Free air passage on appointment. There is no income tax in the Sudan at present.

Write for further particulars and application forms to Sudan Embassy, Personnel Section, Cleveland Row, St. James's, S.W.1, quoting reference Ginning Factories Engineer 4/2420. Closing date 8th March, 1958. E6079

LONDON TRANSPORT

CIVIL ENGINEERS

London Transport require a number of CIVIL ENGINEERS in connection with their New Works Programme, preferably with a University Degree or Graduate Membership of a recognised professional Institution.

Applicants must have had experience in preparation of schemes, estimates, civil engineering design, contract drawings and documents and be capable of controlling staff and supervising works executed by contract. They must have had experience in some of the following types of civil engineering work :—earthworks, drainage, bridging, retaining walls, heavy foundations, R.C. works, tunnelling, general railway construction.

Salary range, according to ability, qualifications and experience, from £790 to £1155. Medical examination ; free travel.—Applications within 7 days to Staff and Welfare Officer (F/EV 668), London Transport, 55, Broadway, S.W.1. E6142

TENDERS

AUCKLAND HARBOUR BOARD

NEW ZEALAND

TENDERS FOR CONSTRUCTION OF FREYBERG WHARF

TENDERS are invited for the CONSTRUCTION of a REINFORCED CONCRETE PILED WHARF, having berths for two overseas ships and comprising 24,500 sq. yds. of reinforced concrete deck, steel sheet pile breastworks, stone banks, formation of approaches and services at Auckland, New Zealand.

Contract documents and plans may be obtained from Auckland Harbour Board, Auckland, New Zealand, or William Coward and Co., 3, St. James's Square, London, S.W.1.

Tenders close at Auckland 30th June, 1958.

V. A. C. CHRISTIANSEN
Secretary.
E5093

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E721 x

FREE ! Brochure giving details of Courses in Mechanical and Production Engineering, Draughtsmanship, &c., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other professional examinations. —E.M.I. Institutes, Dept. E.30, London, W.4. (Associated with H.M.V.). E972 x

Classified Advts. continued on page 134

EDUCATIONAL

THE INSTITUTION OF ELECTRICAL ENGINEERS

INSTITUTION SCHOLARSHIPS

The Council invite applications for the following Scholarships, which are offered for award this year.

RESEARCH SCHOLARSHIPS—Ferranti, value £500 per annum for two years; I.M.E.A., value £420 for one year, may be extended; Oliver Lodge, value £420 for one year, may be extended; Swan Memorial, value £120 for one year (this may be increased in exceptional circumstances); C. P. Sparks War Thanksgiving Fund, maximum grant of £100.

GRADUATE SCHOLARSHIPS—for full-time post-graduate study. Duddell, value £400 for one year; Silvanus Thompson, value £400 for one year.

STUDENT SCHOLARSHIPS—for study at undergraduate level at a university or a technical college. Duddell, value £200 per annum for three years; Silvanus Thompson, value £200 per annum for three years; Sir Arthur Fleming, £120 per annum for four years; Paul, £75 per annum for four years (this may be increased to a maximum of £150 for a meritorious student); Salomons, value £60 for one year; David Hughes, value £60 for one year; Sir Charles A. Parsons, value £60 per annum for three years; Thorrowgood, value £25 for one year.

The closing date for the receipt of applications is the 1st May, 1958, for Student Scholarships, and 2nd June, 1958, for Graduate and Research Scholarships. —Further particulars and nomination forms may be obtained from the Secretary, The Institution of Electrical Engineers, Savoy Place, London, W.C.2. E6116 E

THE COLLEGE OF AERONAUTICS

SCHOLARSHIP

Applications are invited for the PERRING SCHOLARSHIP IN AERONAUTICS, valued £500 per annum, tenable at the College of Aeronautics. The successful candidate will be admitted to the two-year course at the College.

Applicants should preferably be Honours Graduates or Final Year Undergraduates in Engineering, Mathematics or Physics; applications from non-Graduates with comparable qualifications will also be considered. Candidates must be British subjects domiciled in the United Kingdom.

Forms of application and statement of conditions will be forwarded on written application to The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

The closing date for the receipt of applications is 18th May, 1958. E6127 E

THE UNIVERSITY OF SOUTHAMPTON

I.C.I. RESEARCH FELLOWSHIPS

Applications are invited for I.C.I. RESEARCH FELLOWSHIPS IN CHEMISTRY, ENGINEERING and PHYSICS, to which some appointments may be made during the current academic year. The appointments will date from 1st October, 1958, or earlier if a selected candidate is available before that date. Salary according to qualifications and experience within range £700–£1000 per annum. F.S.S.U. and children's allowance.—Applications (15 copies), containing list of publications and names of two referees, should be sent not later than 29th March, 1958, to the Secretary and Registrar, from whom further particulars may be obtained. E6129 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED

A CIVIL ENGINEER OR ENGINEERING GEOLOGIST urgently required to take charge of site investigation for very large dam in West Pakistan. Applicants must have previous experience of large-scale site investigations and preferably some knowledge of soil mechanics laboratory work. Salary range £2300–£3000, depending on experience. Applications, giving detailed accounts of education, qualifications and previous experience, will be treated confidentially by the Consulting Engineers, Binnie, Deacon and Gourley, Artillery House, Artillery Row, London, S.W.1. E6101 A

BABCOCK AND WILCOX, LIMITED, ATOMIC ENERGY DEPARTMENT

require a selected number of QUALIFIED ENGINEERS in this rapidly developing field. Experience in heat transfer, high-temperature components or general mechanical and electrical design would be an advantage. Willingness to travel for limited periods in connection with overseas projects desirable.

Write, giving full details of past experience, to:
Assistant Secretary,
BABCOCK AND WILCOX, LIMITED,
209, Euston Road,
LONDON, N.W.1. E6135 A

ASSISTANT TO TECHNICAL DIRECTOR required by small/medium marine diesel engine builders. The applicant should be familiar with design and contract drawing-office procedure, engine testing and development work and general administration of a technical department, including direct contact with customers. Previous marine experience would be an advantage. Please give details of past experience and academic progress in chronological order, noting particularly the degree of responsibility involved at each stage. Replies will be treated in strictest confidence and all applications will be acknowledged. Age should be 25/35.—BOX No. E1616, "The Engineer." A

CALTEX PACIFIC OIL COMPANY MECHANICAL ENGINEER

Applications are invited for this position in Sumatra, where the company is developing new oilfields in jungle areas.

Candidates, not over forty years of age, must have attained A.M.I.Mech.E. and have ten or more years' experience in the design and installation of small tank farms and gathering station pumphouses, generating plants, workshops, and of the pipe runs and manifolds connected therewith. Their experience should preferably include similar work in an oilfield.

A salary commensurate with qualifications and experience can be offered in addition to which adequate living allowances are given with medical attention, paid local and home leave and participation in pension plan.

Please write, giving full particulars and quoting "SUM," to Caltex Services, Limited, Caltex House, Knightsbridge Green, London, S.W.1. E5067 A

CHIEF DRAUGHTSMAN required by a large engineering company to take charge of their London design offices, situated in the West End. The successful applicant must have very sound experience of mechanical and/or structural engineering, and be an A.M.I.Mech.E., also able to administrate a staff of 17 men, and negotiate with customers and potential customers.—Please apply, with full particulars, quoting "Director," to BOX No. E9749, "The Engineer."

CIVIL AND STRUCTURAL ENGINEERS AND DRAUGHTSMEN required for permanent appointments, preferably with experience in reinforced concrete. Attractive salaries paid and, in many cases, accommodation allowance. Positions which attract accommodation allowance may involve periodic changes of location. Reply, giving full details of age, experience, qualifications, &c.—BOX No. E6021, "The Engineer." A

CIVIL ENGINEER required for technical sales department. Must have first-class experience of tendering on civil engineering projects involving all types of earth-moving equipment and be capable of producing schemes, together with drawings, for the operation of shovels, draglines, crawler tractors and towed scrapers, motor scrapers, and truck operations. Applicants should be capable of estimating outputs of all such types of equipment on specific operations and have a good knowledge of contractors' operations throughout the U.K. Apply with full details.—BOX No. E1625, "The Engineer." A

COMBUSTION ENGINEERING ASSISTANT (age around 35), good technical qualifications and experience of design of burner equipment, required for gas burner department. Competent to attend occasionally at commissioning of large industrial burners. Good salary and superannuation scheme. —Write, giving details of experience, age and salary required, to Liptak, Ltd., 68, Victoria Street, London S.W.1. E1614 A

DESIGN ENGINEER, Graduate or equivalent qualification, competent in stress calculations, with railway rolling stock experience preferred, but not essential, required for important design projects by a progressive company in the East Midlands. Pension and life assurance scheme in operation. Apply in confidence, giving full details of education and experience.—BOX No. E6141, "The Engineer." A

DESIGN ENGINEER, with wide experience of electro-hydraulic mechanisms, required by a substantial firm of engineers in the WINDSOR/SLOUGH area. The person appointed will be required to work from the drawing board and must be an accomplished draughtsman. He will be required to initiate new designs and take full responsibility for development of light electro-mechanical and hydraulic mechanisms. Commencing salary will be £1200, plus production bonus. The appointee will hold executive rank, and be directly responsible to the Chief Engineer. A superannuation scheme is in operation.—Please send applications with full details of experience to BOX TE. 950, c/o 191, Gresham House, E.C.2. E6055 A

DESIGNER, H.N.C. or equivalent, familiar with steam or diesel engines and compressors, wanted by West Midlands engineering firm. Initiative and experience required suitable for a future Head of Design Department. Immediate preparation of suitable applicant for this position is intended; age 35/50. Commencing salary £850 p.a. minimum. Pension scheme, canteen and help with accommodation. Apply with particulars.—BOX No. E6126, "The Engineer." A

DESIGNER-ESTIMATOR required by a well-established firm of Sewage Pump manufacturers in the Midlands. Successful applicant would be engaged upon the design, development and estimating for centrifugal sewage pumps and accessories. Replies should give the usual personal particulars, together with details of previous experience and salary required.—BOX No. E1575, "The Engineer." A

DRAUGHTSMAN (SENIOR), having experience in machine design and works layouts. A knowledge of works building design desirable, but not essential. Technical education to at least O.N.C. standard. DRAUGHTSMAN (JUNIOR) for general engineering design or jig and tool design.—Applicants are invited to submit full details of age, experience and salary required, to the Personnel Manager, Ferodo, Limited, Chapel-en-le-Frith, Via Stockport. E6056 A

DRAUGHTSMEN required, for interesting work in connection with the construction of a new integrated steelworks. Men with experience of either coke ovens, blast-furnaces, open-hearth steel furnaces and rolling mills preferred, but other heavy mechanical or structural experience will be considered. Salary according to qualifications.—Apply to Labour Manager, South Durham Steel and Iron Co., Ltd., Mainsforth Terrace, West Hartlepool. E1622 A

ELECTRICAL/MECHANICAL ENGINEER (Assistant) required for Alluvial GOLDMINE in BRITISH GUIANA. Age about 25/35, preferably single, with good practical experience, particularly on electrical side in operation and maintenance of diesel power plant, hydro-electric plant and dredging equipment. Free accommodation. Inclusive starting salary £1050 to £1250 p.a., depending on experience. Kit allowance, pension scheme, free passages, generous leave on full pay, tours of duty 2½ years.—Apply, giving age and full particulars, to Personnel Officer, Colonial Development Corporation, 33, Hill Street, London, W.1, quoting Serial 326. E6132 A

ELECTRICAL ENGINEERING DRAUGHTSMAN

Electrical Engineering Draughtsman required, with sound experience in design of general installation and subsequent maintenance of H.T. substation and distribution in a large factory in North West. Application, giving age and full details of experience and salary required.—BOX No. E6123, "The Engineer." A

ENGINEER
required in
DEVELOPMENT LABORATORIES

for stress analysis and vibration problems.

Applicants should have a good Degree in Mechanical Engineering, together with ability to make a mathematical approach to problems. Some experience in industry and in the use of electronic equipment is desirable.

The position carries an attractive starting salary and provides excellent opportunities for further advancement. Staff pension fund.

Apply in writing, stating age, qualifications and experience, to the Personnel Manager, JOSEPH LUCAS (ELECTRICAL), LIMITED, Great King Street, Birmingham, 19, quoting reference PM/D/192. E996 A

ENGINEER BUYERS AND REPRESENTATIVES' ASSOCIATION (Limited by Guarantee). The Council of this dominant professional organisation can fill vacancies for Engineer Buyers and Engineer-Representatives (no fees—employers or members)—and to consider application for membership from qualified Buyers and Representatives associated with the Engineering and Allied Trades.—Write E.B.R.A., 47, Victoria Street, London, S.W.1. Tel.: ABB 3583 (Employment Licence No. 6063). Licensed annually by the L.C.C. E627 A

ENGINEER - DRAUGHTSMAN required by London firm of general mechanical engineers. Experience of conveyors or bottling machinery desirable. Interesting work requiring initiative and responsibility. Starting salary £1000 p.a. Good prospects, pension scheme, canteen. Please write fully.—BOX No. E6098, "The Engineer." A

ENGINEER OR DRAUGHTSMAN, with experience of heating and ventilating, for the preparation of comprehensive industrial air-conditioning schemes, incorporating direct dehumidifiers and for technical sales discussions with customers. The work requires energy and initiative and there is considerable variety in the development of this modern equipment in our Dryer Division which is moving shortly to a new works and offices in Aldridge, South Staffordshire.—Apply to Personnel Manager (TCS), Birlec, Limited, Tyburn Road, Erdington, Birmingham, 24. E6109 A

ENGINEER REQUIRED, to supervise research and development work on oil burners for marine and land work. Applicants should possess a University Degree in Engineering and be vitally interested in combustion engineering. Excellent remuneration and conditions, and good prospects for successful candidate. Please state age, experience and an indication of salary required.—BOX No. E6099, "The Engineer." A

ENGINEER/SURVEYORS required immediately for medium-size road and sewer contracts in London area and Essex. Good prospects for young men.—Write, in confidence, The Secretary, Fitzpatrick and Son (Contrs.), Ltd., 455, Old Ford Road, Bow, London, E.3, stating age, experience, salary required, &c. E1596 A

ENGINEERING INSURANCE COMPANY invites applications from Engineers, not over 35 years of age, who possess First Class M.O.T. Certificate (Steam) for position as ENGINEER SURVEYOR in London and surrounding districts. Progressive salary scale commencing at £735 and rising to over £1000 per annum, plus expenses and allowances. Non-contributory pension scheme and other staff schemes. Apply in own handwriting.—BOX No. E6022, "The Engineer." A

GAS TURBINE DESIGN ENGINEER required for work on industrial and marine sets. The work includes thermodynamic design of compressors and turbines, cycle assessment, performance prediction, heat transfer calculations and major stressing.

Applicants should hold University Degree or equivalent, but previous experience of gas turbines is not essential.

Good pension scheme, excellent amenities and assistance towards moving.

Applications, stating qualifications, experience and salary required, should be made to The Personnel Manager,
W. H. ALLEN, SONS AND CO., LTD.,
QUEENS ENGINEERING WORKS,
BEDFORD. E6052 A

EXPERIENCED DRAUGHTSMEN, of O.N.C. or H.N.C. standard, required for interesting design work on process plant and machinery. A good technical background and knowledge of machine design is essential and applicants should be qualified to H.N.C. standard. Salaries are assessed in accordance with age, qualifications and experience, and will be reviewed annually. Contributory superannuation and widow's pension fund are in operation and there are excellent canteen, welfare and recreational facilities.—Applicants should apply in writing to Group Personnel Department, Pilkington Brothers, Limited, Grove Street, St. Helens, enclosing a brief history of their career and details of their education and qualifications. E6047 A

HEAT TRANSFER AND FLUID FLOW.—RESEARCH AND DEVELOPMENT ENGINEER required by an old-established engineering company in the Glasgow area. Applicants, aged 25–30, should have a University Honours Degree in Engineering and some research experience. The work would involve the theoretical design and practical testing of new types of heat exchanger. A good salary would be paid to an applicant with the necessary qualifications. Apply, giving age and full particulars.—BOX No. E788, "The Engineer." A

INSTRUMENTATION DESIGNER-DRAUGHTSMEN required in the Middlesbrough area. Attractive salary and allowances. Pensionable appointments.—BOX No. E6060, "The Engineer." A

INTERNATIONAL LIAISON ENGINEER

The prospect of European Free Trade has prompted several companies concerned with the manufacture of a range of light engineering products to establish a technical agreement and to share common research services. Companies in Germany, France and Britain are involved. A vacancy has therefore arisen for an Engineer to be responsible for the operation and interpretation of the technical agreement, and for providing liaison between the companies. A sound background of mechanical engineering is required, preferably including professional qualification, and experience in the automotive industry would be an advantage. The person appointed must be capable of conducting technical discussions in French, German and English. He will be required to reside in the Midlands area of England, and to visit European countries as required; he will be executively responsible to the Managing Director of the British company. In the early stages this work may be less than full-time, and other related technical work will be provided.

The salary offered will interest men earning in excess of £1000 per annum, and pension and other benefits are of a high standard. Applicants should write, stating their engineering and linguistic training and experience, with other personal details, including age.—BOX No. E6125, "The Engineer." A

JUNIOR DRAUGHTSMAN required, experience in mechanical handling plant an advantage. Good prospects.—British Industrial Sand, Ltd., High Street, Godstone, Surrey. E1608 A

JOHN LAING AND SON, LIMITED

invite applications for MOBILE SITE STAFF on a variety of building and civil engineering contracts throughout the country. Vacancies exist in the following grades:—

CIVIL ENGINEERS
for contract supervision and also for general site engineering services. Professional qualifications expected for those seeking senior posts, but applications also welcome from men with good instrument experience. Age 35–50.

SITE AGENTS
SUB-AGENTS
GENERAL FOREMEN AND GANGERS
Preference given to those who can offer sound supervisory experience on a wide variety of contract work. Age 30–50.

BUILDER ASSISTANTS
for detail progressing and other site duties. Preferably O.N.C. or H.N.C. Age 25–35.

CHECKERS
STOREKEEPERS AND ACCOUNTS CLERKS
with good general experience. Age 25–40.

The company has an established policy of employment security, and those who prove themselves can expect good prospects. Those interested should write for application form, stating vacancy sought, to:—

Personnel Manager (G.10),
JOHN LAING AND SON, LIMITED,
Building and Civil Engineering Contractors,
PAGE STREET, N.W.7. E6118 A

JOSEPH LUCAS (ELECTRICAL), LIMITED,
have vacancies for
ASSISTANT DEVELOPMENT ENGINEERS

to work on the design and development of automobile generators, alternators and starting motors and also of motor-cycle electrical equipment, including equipment to be used for racing purposes. Applicants should be of Higher National standard and should have had previous experience in electrical design. Five-day week, staff pension fund.

Apply in writing, stating age, qualifications and experience, to the PERSONNEL MANAGER, JOSEPH LUCAS (ELECTRICAL), LIMITED, Great King Street, Birmingham, 19, quoting reference PM/D/176. E995 A

JUNIOR INSTRUMENT DRAUGHTSMEN, having completed National Service, required for work on large chemical plant installations. A.E.S.D. minimum rates or above. Five-day week and superannuation scheme.—Apply by letter, giving details of technical education to the Chief Draughtsman, Laporte Chemicals, Limited, Clifton House, Euston Road, London, N.W.1. E9988 A

SITUATIONS VACANT

MACHINE TOOL MAKER'S ADVERTISING DEPARTMENT require WRITER for Catalogues, Instruction Sheets, Editorials, &c. Knowledge of machine tools, presses and sheet metal machines useful. Non-contributory pension scheme.—F. J. Edwards, Ltd., 359, Euston Road, N.W.1 (EUSton 4681). E6131 A

MANAGER REQUIRED, to assist heating engineering contractor in London. Excellent moderate-sized concern requiring to be expanded. Sound design knowledge and contracting experience essential. Write, stating experience.—BOX No. E1624, "The Engineer." A

MECHANICAL DESIGN DRAUGHTSMAN required, Manchester district, for a responsible position in connection with an atomic energy project. Experience in the design of pressure vessels and associated pipework essential; a knowledge of the estimating of this type of equipment will be an advantage. Candidates should possess at least an H.N.C. in Mechanical Engineering. An attractive salary, commensurate with experience and qualifications, will be available. Apply, in confidence, stating age, experience, &c.—BOX No. E6039, "The Engineer." A

MECHANICAL ENGINEERS are invited to apply for vacancies in the Chief Engineer's Department of a very active and flourishing heavy chemical industry of international standing. The continuing post-war expansion of the company has been associated with a large number of interesting mechanical engineering design problems in existing and future plants and processes. Preference will be given to candidates with a University Degree in Mechanical Engineering, but those with equivalent professional qualifications will also be considered. The location of these appointments is the North-East of England. The age envisaged is 25–35, and the salary will normally be in the range of £1000 to £1470 per annum. There are, however, some senior posts for which the salaries are substantially higher and in addition there is an annual bonus. Other conditions of service include attractive pension and life assurance schemes; housing assistance is available if required. Applications, quoting reference ME.13, should be made in writing.—BOX No. E218, "The Engineer." A

PRODUCTION ENGINEER required, with wide experience of reconditioning general plant. Only competent keen executive considered. House available, pension scheme. References required.—Fred Watkins (Engineering), Ltd., Coleford, Glos. E6059 A

MUNICIPAL MUTUAL INSURANCE, LTD., has vacancies for ENGINEER SURVEYORS in London, Birmingham, Bradford and Manchester. Posts are pensionable and permanent to satisfactory candidates who should have served an apprenticeship and have sound practical and theoretical knowledge. Technical qualifications: First Class Ministry of Transport Certificate. Salary, £735–£1060 per annum.—Apply in own handwriting, marking the envelope "Application Engineer Surveyor" and "Private and Confidential," to the Chief Engineer, 22, Old Queen Street, Westminster, S.W.1. E6086 A

NATIONAL ESTABLISHED ENGINEERING CONSULTANTS require, for their Bristol office, MECHANICAL ENGINEER, with design experience of mechanical handling, plant work, or heating and ventilating. Minimum requirements are a Degree or A.M.I.M.E., plus seven years' experience in industry. Salary £1100–£1200 per annum. Pension scheme.—BOX No. E6112, "The Engineer." A

PLANT MAINTENANCE ENGINEER, for heavy chemicals industry, age 35/45, with practical and design experience, together with some administration experience. Applicants should hold H.N.C. in Mechanical Engineering or equivalent. Modern factory with canteen facilities. Contributory pension scheme in operation. Housing facilities available.—Apply to Works Manager, Murgatroyd's Salt and Chemical Co., Ltd., Elworth, Sandbach, Cheshire. E1626 A

PRODUCTION ENGINEER and Assistant to the Managing Director required by small progressive engineering firm. Excellent opportunity for young engineer with initiative, and willing to accept responsibility.—BOX No. E6084, "The Engineer." A

PROMINENT FIRM OF BUILDING AND CIVIL ENGINEERING CONTRACTORS require young QUALIFIED MECHANICAL ENGINEERS or applicants who have completed indentured apprenticeships as Fitters and Turners, with Higher National Certificate, for posts in the plant organisation relating to inspection, overhaul and repairs to contractors' plant in the U.K. Excellent prospects of advancement providing those selected prove satisfactory after a probationary period, when entry to pension fund will be considered.—Applications, giving details of experience and qualifications, to BOX No. E6010, "The Engineer." A

QUALIFIED ENGINEER required as Technical Assistant to Managing Director of London company dealing with refractory and insulation contracts for steam-raising plant and specialist constructions in oil, chemical, steel and allied industries. Applicants must have University Degree and/or equivalent professional qualification; age 28–35. Excellent prospects. Salary £1500 p.a.—Write to BOX No. D5343, c/o White's, Ltd., 72, Fleet Street, E.C.4. E6078 A

QUALIFIED PRODUCTION ENGINEER required for senior position with a medium-sized precision engineering company in Surrey. Applicants should be between 40 and 50 years old and possess either B.Sc. (Eng.) or A.M.I.Mech.E. Practical commercial experience essential. The prospects are good. Applications, which will be treated in strict confidence, should give the fullest details of career, health and present occupation.—BOX No. E6085, "The Engineer." A

QUALIFIED YOUNG ENGINEER, with some writing ability, required in London bureau of leading American publishers of technical journals. The applicant should have design experience in the mechanical engineering field with at least an understanding of electrical systems. Post calls for selective and critical reporting of both mechanical and electrical product engineering developments in Europe.—BOX No. E6124, "The Engineer." A

SENIOR DRAUGHTSMAN required for drawing-office section engaged on the application of small diesel engines to marine propulsion. Experience on this type of work is essential. There is every likelihood that this section will expand considerably in the near future and the successful applicant will have the opportunity of promotion to Section Leader. Excellent salary and conditions of employment, including non-contributory pension scheme.—Apply in writing, giving full details, to the Chief Personnel Officer, Petters, Ltd., Causeway Works, Staines, Middlesex (Tel.: Staines 1122). E6137 A

SENIOR ENGINEER/SCIENTIST required in the N.C.B.'s Carbonisation Dept. in London, for development and design work on new processes for carbonised and briquetted fuels. A qualification of good Degree standard in a suitable subject (e.g. Fuel Technology, Chemical, Gas or Mechanical Engineering or similar subject) is required, combined with considerable practical experience in responsible positions and administrative ability. Salary £1900–£2550. (Ref. X1059C.) TWO ASSISTANTS for the above work are also required, having a suitable qualification of at least H.N.C. standard and some practical experience. Salary £900–£1500 (Ref. X1060C). Appointments within the inclusive ranges stated will depend on qualifications and experience. The posts are pensionable.—Write, quoting relevant reference number, to National Coal Board, Staff Dept., Hobart House, London, S.W.1, for application form, which should be returned by 27th February, 1958. E6074 A

SENIOR LIAISON ENGINEER.—Applications for this appointment are invited from men between 25 and 35 years of age. Minimum requirements are H.N.C. in Mechanical or Production Engineering, and not less than 5 years' experience in a design office and several years' workshop practice. Preference will be given to those applicants who have served an engineering apprenticeship, and some experience of the design of special-purpose machinery would be considered a distinct advantage. The selected candidate, who will be a senior member of the planning staff, will assume control of the drawing-office and be called upon to discuss production and design problems with customers. The position calls for initiative and responsibility, and offers every opportunity for progress. The initial salary will be in the neighbourhood of £1000 per annum; conditions of work are excellent; profit-sharing and pension schemes are in operation, and assistance with housing is available if required.—Applications, stating age, qualifications and full details of experience, should be sent to BOX No. E1607, "The Engineer." A

SETTER MECHANIC, with experience of automatic packaging machine, required for a well-known pharmaceutical company, N. London. A generous non-contributory pension scheme is in operation and a good starting salary with regular reviews is offered.—Apply, giving full details and present salary, Personnel Manager, BOX No. E6088, "The Engineer." A

SENIOR MECHANICAL ENGINEER. — A vacancy exists for a Mechanical Engineer, aged over 30, and interested in metrology. Duties will be to take charge of a team being formed to design and develop gauges, study the capabilities of mass production machines for small parts, and to give an advisory service on metrology and inspection standards. Minimum qualifications will normally be H.N.C. and further training will be given.—Apply in writing to the Plant Personnel Officer, The Mullard Radio Valve Co., Ltd., New Road, Mitcham Junction, Surrey. E6100 A

SENIOR WORK STUDY ENGINEER for work study department in expanding company manufacturing heavy electrical equipment in West London area. H.N.C. Mechanical and sound practical training essential. Write full details of career and salary required.—BOX No. E1599, "The Engineer." A

SITE ENGINEER required, to supervise the construction of welded oil storage tanks. Position incorporates non-contributory pension scheme. Apply, stating age, qualifications and previous experience.—BOX No. E6139, "The Engineer." A

THE BRITISH STEEL PILING CO., LTD., require a CIVIL ENGINEERING ASSISTANT, aged about 25 to 30, for their London office. The work will involve the design of steel sheet pile retaining walls for all types of civil engineering structures, as well as cofferdams and bearing pile foundations. An Engineering Degree or equivalent qualifications are required. Previous experience of steel piling and soil mechanics is not essential, though desirable.—Apply in writing only, giving details of qualifications and experience, and stating age and salary required, to the Company at 10, Haymarket, S.W.1, marking the envelope "Engineering Assistant." E1620 A

THE MOTHERWELL BRIDGE AND ENGINEERING CO., LTD.,

offer an Excellent Opportunity to a

SENIOR CONSTRUCTION ENGINEER

aged 35 to 45, to work at the Atomic Power Station at Hunterston, West Kilbride, Ayrshire. Applicants should have extensive experience in major site work, preferably refinery construction. Attractive remuneration for suitable man.

The Directors regard this position as a stepping stone to complete control of the company's work on a future atomic power station.

The Motherwell Bridge and Engineering Co., Ltd., are members of the G.E.C./Simon-Carves Group for undertaking work on

ATOMIC POWER STATIONS

Apply, giving particulars of previous experience, to The Motherwell Bridge and Engineering Co., Ltd., P.O. Box 4, Motherwell. E6077 A

THE REED PAPER GROUP
invites applications from
EXPERIENCED DRAUGHTSMEN
(MECHANICAL)
for newly created additional vacancies in the engineering drawing-office.

Qualifications: National Certificate (Mechanical Engineering) or equivalent. Applicants studying for Higher National will be considered. Previous drawing experience essential and paper-making experience an advantage.

Age: 25–35.

Conditions: good starting salary; monthly staff status; 3 weeks' holiday; non-contributory pension, staff sickness and assisted house purchase schemes; social and sports club; canteen.

Applications, in writing, stating age, qualifications and experience, to the Personnel Officer, Empire Paper Mills, Limited, Greenhithe, Kent, quoting ref. D/4. Closing date, 28th February, 1958. E6134 A

THE STANTON IRONWORKS COMPANY, LIMITED, Near Nottingham, has a vacancy for a young ENGINEER as Personal Assistant to the Chief Works Maintenance Engineer. He will act as liaison between the Chief Works Maintenance Engineer and various works departments, keeping close personal contact with plant engineers and production officials. The position offers considerable scope for acquiring experience and advancement. It is superannuated. Write, in confidence, to the Staffing Officer, with age and full details of experience. E6075 A

THE SUPERHEATER COMPANY, LIMITED,
53, HAYMARKET, LONDON, S.W.1
require SENIOR DRAUGHTSMEN and CHECKERS for their London office. Experience in steam boiler plant preferred, but not essential. Permanent and pensionable positions affording good prospects for suitable men. Applications are invited to the Secretary, giving full details of qualifications and experience. E6023 A

TWO DESIGNER-DRAUGHTSMEN are required for work on liquid fuel combustion equipment and heat exchangers for industrial use. Previous experience of this type of work is not essential, although an appreciation of fluid flow problems is necessary. Candidates should be of H.N.C. standard and should have a good knowledge of modern drawing-office procedure. Prospects of promotion are good.—Apply, Technical Manager, White's Marine Engineering Co., Limited, Hebburn on Tyne. E6026 A

UNILEVER, LIMITED, invite applications for the appointment of MECHANICAL ENGINEERING DRAUGHTSMEN and DRAUGHTSMEN/DESIGNERS in their London office. Qualifications equivalent to Higher National Certificate preferred and some workshop training is essential. Experience required in layout drawings for processing equipment and design of vessels and pipework. Starting salaries according to age and experience.—Written applications, giving full particulars of qualifications, training and experience, to be addressed to Head Office Staff Department (WF 24), Unilever House, London, E.C.4. E6103 A

Classified Advts. continued on page 136

BOOKS and PUBLICATIONS

PITMAN TECHNICAL BOOKS

Parker Street, Kingsway, London, W.C.2.

ELECTRICAL TECHNOLOGY (M.K.S. UNITS)
By H. COTTON, M.B.E., D.Sc., M.I.E.E. 7th Edition.
A new and completely revised edition of Professor Cotton's famous work. In this edition the M.K.S. system of units has been adopted but the previous edition will still be available for those who do not want to use the M.K.S. system. An invaluable work for the electrical engineering degree student. Pitman's "Engineering Degree Series." 50/- net.

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THE SUPERHEATER COMPANY, LIMITED,
POWER PLANT DIVISION
53, HAYMARKET, LONDON, S.W.1

require ENGINEERS having Degree or equivalent qualification for the Power Plant Division. The posts involve travelling to various power plant sites in the British Isles, but the successful applicants will be required to live in the London area. Previous experience in steam plant, though desirable, is not essential.—Applications are invited, in the first instance, to the Secretary at the above address, giving full details of age, qualifications and experience.

E6024 A

WORKS ENGINEER required, to control maintenance and installation work in large food factory in the Liverpool area. Candidate should have University Degree and/or A.M.I.Mech.E., with, preferably, experience of maintenance planning in a process industry and a good knowledge of steam, electricity, gas, water and compressed air services. Age limits approximately 32–45 years. Progressive salary in accordance with qualifications and experience, but not less than £1200 per annum. Pension scheme and other welfare facilities available. Assistance with house purchase may be arranged.—Please apply to the Chief Engineer, BOX No. D.428, Lee and Nightingale, Liverpool, giving full details of training and experience. E6108 A

SITUATIONS VACANT

SENIOR ENGINEER (MECHANICAL)

with experience in the design of pressure vessels and high pressure systems required to lead a team engaged on new designs in connection with large scale process plant. Good Engineering Degree essential.

Commencing salary up to

£1,900 p.a.

Applications to Box No. E6082, *"The Engineer."*

A

SITUATIONS VACANT

MECHANICAL ENGINEERING DRAUGHTSMEN

are required for training in

TYRE DESIGN

Applications are invited from draughtsmen, aged up to 28 years, with at least O.N.C. in Mechanical Engineering, for interesting posts in our Tyre Design Division.

This type of work should be attractive to young men with an interest in design and development. The Tyre Design Division works in close co-operation with other divisions of the Tyre Technical Department, so that a wide range of Problems will be encountered.

Those interested should write in confidence, giving age, experience so far and salary expected, to the

PERSONNEL MANAGER, (T.D.), FORT DUNLOP, ERDINGTON, BIRMINGHAM, 24.

E6072 A

DESIGNER-DRAUGHTSMEN

INSTRUMENT

ELECTRICAL

PRESSURE VESSELS

& HEAT EXCHANGERS

Designer-Draughtsmen in these categories are cordially invited to contact KELLOGG INTERNATIONAL CORPORATION, leading Design and Construction Engineers of world-wide repute in the petroleum and chemical industries. We provide good working conditions and excellent personnel benefits with opportunities for advancement, and have immediate vacancies in our new additional premises. Please write to the Personnel Manager,

KELLOGG INTERNATIONAL CORPORATION 7-10 CHANDOS STREET, LONDON, W.1 *or telephone MUS 4010 quoting reference 124/G*

E6110 A

SENIOR MECHANICAL ENGINEER

(Turbines—Pumps—Compressors)

Applications are invited for appointment as a Senior Mechanical Engineer, carrying responsibility for the specification and design of rotary and reciprocating pumps, high pressure compressors and turbines.

The designs are complementary to large scale plant installations under home and overseas design and construction contracts. The post is based in London and offers the opportunity of an excellent salary and a most interesting range of work. An engineering degree or membership of the Institution of Mechanical Engineers is essential.

Housing need offer no problem

Applications, giving full information on age, qualifications, experience and present salary to:

The Personnel Manager (Ref. GH/5)

BRITISH OXYGEN ENGINEERING LIMITED
ANGEL ROAD, UPPER EDMONTON, LONDON, N.18.

E6107 A

ENGINEERING DEVELOPMENT

ENGINEERS of high calibre are needed by the National Coal Board at their newly built Central Engineering Establishment at Stanhope Bretby, near Burton-on-Trent.

They will develop and test all forms of machinery and equipment for cutting, loading and transporting coal, for driving underground roadways, for strata control, and for coal preparation—in short, for all the varied engineering activities associated with modern techniques of mining coal. Such work is done either at the Establishment or by outside manufacturers working to its requirements.

There are excellent design facilities, workshops and laboratories; also a proving ground for full-scale trials. Projects are handled by balanced teams, which include Design Engineers, Mechanical Engineers (including structural and hydraulic specialists) and Electrical Engineers (including control and instrumentation specialists.

The vacancies are for :

(i) PROJECT ENGINEERS, for the technical investigation and specification of projects, and their co-ordination and control.
(ii) DEVELOPMENT ENGINEERS, for designing machines and special equipments to satisfy users' specifications.
(iii) PROVING ENGINEERS, for testing machines and materials at laboratory, proving ground and underground stages of development.
(iv) SPECIAL PROJECT ENGINEERS, for developing coal preparation plant and services allied to chemical engineering.

Salaries will depend on the ability and experience of candidates, and the responsibilities of the different vacancies : some will range above £2000 p.a.; others, in lower ranges, should prove attractive to well-qualified younger engineers, for whom existing conditions and future prospects are excellent.

Engineers interested in this type of creative work are invited to write or telephone for application forms to National Coal Board, Staff Dept. (X1057G), Hobart House, London, S.W.1 ('phone, SLO 3401, Ext. 543), indicating work preferred. The forms should be returned by 24th February, 1958. E6040 A

SENIOR WORK STUDY ENGINEER

An excellent opportunity exists with a well-known Company manufacturing for the electric supply industry for a young and enthusiastic Graduate with the requisite training and background to assist in establishing Work Study throughout the organisation.

The position, which is a senior one, entails responsibility for Work Study investigations at various factories and the dissemination of Work Study principles. Sound basic training in this field is essential with wide experience in applying Work Study techniques, Labour Costing, etc. Some experience in group discussion and lecturing would be an advantage.

An attractive salary in the four figure range will be paid, with scope for advancement.

BOX No. E6087 " The Engineer " A

WILTON ICI WORKS

MIDDLESBROUGH

has vacancies for

ASSISTANT TECHNICAL OFFICERS

FOR

ENGINEERING DESIGN

The scene of Britain's largest chemical project, Wilton Works, is on a 2000 acre site near the Cleveland Hills. Development consists of building plants which embody the most up-to-date designs of building, civil engineering and mechanical engineering including a complete Power Station. It also includes electrical engineering in a wide variety covering the generation, distribution, power and lighting installations.

Applications are invited from men who possess Higher National Certificate or its equivalent who are experienced in :—

MECHANICAL DESIGNING

After joining the staff, married men receive a reasonable refund of removal and travel expenses, and facilities are available in approved cases for substantial loans for house purchase ; legal charges will also be advanced. A lodging allowance will be paid to married men selected, whilst they are maintaining two homes. Please write to me: Staff Manager, Imperial Chemical Industries Limited, Wilton Works, Middlesbrough, Yorkshire, quoting reference 461/4.

E6102 A

SITUATIONS VACANT

MICHELIN TYRE CO. LTD.,

Stoke-on-Trent

have progressive openings for

DESIGNER/DRAUGHTSMEN

(*a*) With H.N.C. and preferably Thermo-dynamics endorsement, for interesting work in connection with Works Services—boiler plant, steam and hydraulic applications, pipework.

(*b*) With H.N.C. (mechanical) and experience design of medium to heavy process plant. Some knowledge belt and chain conveyors desirable.

(*c*) With H.N.C. (electrical) or O.N.C., and now studying for H.N.C. for work on motor applications, lighting schemes and general factory electrical services. Good commencing salaries, related to qualifications and experience, are offered, plus a contributory pension scheme, free life assurance and excellen welfare facilities.

Assistance with housing will be given if required.

Please write in confidence to :—(Mr.) J. E. Glendenning, c/o above, quoting reference B2/E.

E9916 A

HEAD WRIGHTSON
IRON & STEEL WORKS ENGINEERING LTD.

PLANT ENGINEER

required for service on

STEELWORKS CONTRACT IN INDIA

Duties cover mechanical/electrical maintenance of heavy structural erection plant. Previous experience with heavy civil engineering plant or similar, preferably overseas, essential. Excellent tax free salary and conditions for three year contract with possibility of extension.

Applications giving details of age, domestic circumstances, qualifications and experience to:—

Personnel Manager, Ref IS/17, Teesdale Iron Works, Thornaby-on-Tees.

E6096 A

British Oxygen Engineering Limited

SENIOR CONSTRUCTION ENGINEER (MECHANICAL)

& CONSTRUCTION ENGINEERS

. . . . for home and overseas contracts for the erection and commissioning of large scale industrial plant and complete process works.

The posts require experience in both the technical and administrative control of construction sites and some specialized experience is required of heavy mechanical plant and of high-pressure process systems. An engineering degree or membership of the Institution of Mechanical Engineers is essential. The post offers excellent prospects in a long-term and expanding field.

Applications, giving full information on age, qualifications, experience and present salary should be addressed to:

The Personnel Manager (GH/2),

BRITISH OXYGEN ENGINEERING LIMITED,

Angel Road, Upper Edmonton, London, N.18.

E6111 A

SITUATIONS VACANT

WELLINGTON TUBE WORKS, LIMITED,
Great Bridge, Tipton.

Applications are invited for the following vacancies in their Tube Fabrication Department :—

STRUCTURAL DESIGNERS, minimum qualification H.N.C. Experienced in the design of buildings, gantries, towers, &c. Structural Design Office experience while esential need not necessarily be in tube as succesful applicants will undergo a period of training within the Company's organisation.

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ESTIMATOR, for compiling estimates from drawings of tubular structures. Practical shop floor experience including machining and welding advantageous.

The structural use of tubes is increasing rapidly and these positions offer considerable scope for advancement in an expanding department.

Applications, stating age, qualifications, experience and salary required should be addressed to :—The Secretary.

E6076 A

DESIGNER

BELL PUNCH CO., LTD., of Uxbridge, require the services of a well-qualified Designer for work on light mechanical and electro-mechanical precision equipment and instruments. Candidate must have had a good general education, have served an engineering apprenticeship, have acquired the Higher National Certificate or its equivalent as a minimum qualification, and possess sound workshop knowledge as a background to his experience in the field of mechanical design work. He should be between the age of 26 and 40 years, and have the ability to work from schematic sketches and produce complete drawings for prototype construction.

The appointment offers considerable scope to a first-class man and a salary according to experience and qualifications of £800 to £1000 per annum is offered. Applications, in confidence, quoting full details of education and experience, should be addressed to Personnel Department.

E6097 A

WORKS STUDY ENGINEER

CHEMSTRAND LIMITED

have a vacancy for a Works Study Engineer in the 28–35 age group at their new factory at Coleraine, Northern Ireland where their acrylic fibre "ACRILAN" will be produced.

Period of specialist training given in U.S.A. on engagement. This appointment offers an exceptionally wide scope of interest and activity to the right man.

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Please apply in confidence with brief personal and career details and current salary to Staff Personnel Manager, Chemstrand Limited, 8, Waterloo Place, London, S.W. 1, quoting ref. CWS/1.

E1615 A

AERO RESEARCH LTD.

(A CIBA Company)

QUALIFIED MECHANICAL ENGINEERS

with some industrial experience are required for interesting new projects. One successful candidate will be asked to manage pilot plant and devise improved production methods, and another will be responsible for detail design and manufacture of equipment for these and other projects. The appointments will carry good salaries and prospects. Applications to the Secretary, Aero Research Ltd., Duxford, Cambridge.

E6071 A

SITUATIONS VACANT

DRAUGHTSMEN

Excellent opportunities are offered to Design and Detail Draughtsmen. The work is on a new project in a rapidly expanding Organisation based on Tyneside. Commencing salaries will be good. Pension and Life Assurance Schemes are in operation. Prospects are excellent. Interviews can be arranged at mutually convenient times and places.—Applicants of H.N.C. standard should write, in strict confidence, to BOX No. E6090 "The Engineer" A

SITUATIONS WANTED

CHARTERED MECHANICAL ENGINEER (36), A.M.I.Mech.E., A.F.R.Ae.S., apprenticed, seeks Managerial Appointment in London or the South of England. Experienced light/medium engineering, design and development, installation, repairs and maintenance, stores purchasing, contracts. Good organiser, drive and personality. Used to dealing all levels.—BOX No. E1632, "The Engineer." B

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MECHANICAL ENGINEER, B.Sc. (Hons.), A.M.I.Mech.E. (32), at present plant engineer. Experienced in special-purpose machinery design and development. Seeks change. Present salary £1350.—BOX No. E1633, "The Engineer." B

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Classified Advts. continued on page 138

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BUSINESSMAN OWNING MODERN ONE-STOREY FACTORY, approximately 30,000 square feet, with ample room for expansion, South Liverpool, willing to consider Partnership in sound business requiring factory space.—BOX No. S.375, Lee and Nightingale, Liverpool. E6117 G

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CASH PAID.
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'Phone: RELiance 7201.
'Grams: "Sotoolsag," London, S.E.11. E210 G

600
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NEW 20,000 c.f.m., 100 p.s.i.g., Electrically-driven TURBO-COMPRESSOR SET by DANIEL ADAMSON, driven through Davey Brown reduction gearbox by Met.-Vick. motor, 4145 b.h.p., 1500 r.p.m., 6600/6300/3/50, with control gear.

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7	17×24	040 Bagnall	1934	160	36
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GOVERNMENT SURPLUS STORES

AUCTION PROGRAMME

		Main Location	*Auctioneers*
February 18–19	**Miscellaneous stores and machine tools**	M.O.S. Storage Depot, **Ruddington, Notts**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
February 25–26	**Miscellaneous stores,** including M.T. spares, tyres, marine engines and spares, bearings, radio spares, etc.	M.O.S. Storage Depot, **Rotherwas, Hereford**	**RUSSELL, BALDWIN & BRIGHT, LTD.** (Dept. L), 20, King Street, Hereford. (Tel.: 4366.)
February 25	**350 vehicles,** including :	62 "B" Vehicle Depot, R.A.O.C., **Eglinton Park, Irvine, Ayr.** (Sale at Central Halls, Bath St., Glasgow, C.2.)	**DIXON & WALLACE** (Dept. L), Bank Buildings, Graham Square, Glasgow, E.1. (Tel.: Bridgeton 2447.)
4 A.E.C. Matadors (diesel), 8 Dennis Max (diesel), 8 Albion Tractors, 16-wheeled 20-ton platform low-loading trailer, 8-wheeled, 18-ton low-loading trailer, Bedford/Scammell tractors, Karrier K.6s, 175 motor cycles, etc.			
February 27	**Machine tools, plant, canteen equipment, office furniture**	Wm. Beardmore & Co., M.O.S. Agency Factory, **Linwood Road, Paisley.** (Sale at Linwood on February 27, and at Central Halls, 25, Bath Street, Glasgow, C.2, on February 28.)	**SHIRLAW ALLAN & CO.** (Dept. L), Keith Street, Hamilton. (Tel.: 63.)
March 5–6	**Machine tools and miscellaneous stores,** including :	Technical Stores Depot, **Old Dalby, Melton Mowbray, Leics.** (Sale at Melton Mowbray.)	**SHOULER & SON** (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 81.)
Centre lathes, miller, bench and pillar drills, welders, washing pumps, electrical test benches and radio instruments, degreasing jenny, woodworking machinery, boot finishing and nailing machines, machine tool spares, Balata and leather belting, welding hose, sewing machines, needles and spares, Coventry dieheads, milling cutters, cloth-cutting machines, mobile electric and other stackers, portable lifting blocks, crab winches, Collis, Morris and Eccles platform trucks, two and four-wheeled hand trucks, paint, varnish, electric generators, engine spares, drawing instruments, spades, lubricating cans, brushes, large quantity of celluloid sheets, cardboard cartons, grease-resisting paper, etc.			
March 12	**Miscellaneous stores**	Central Ordnance Sub-Depot, **Westbury, Wilts.** (Sale at Corn Exchange, Devizes.)	**FARRANT, WIGHTMAN & PINNIGER** (Dept. L), 38, High Street, Swindon, Wilts. (Tel.: 5151/2.)

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E975 I

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INDEX TO ADVERTISERS

PAGE

Abbott & Co. (Newark), Ltd.... 48
Abix (Metal Industries), Ltd.... 9
Accurate Recording Instrument Co. 33
Aeraspray Associated, Ltd. 141
Air Industrial Developments, Ltd. 28
Aiton & Co., Ltd. 41
Alexander, G. H., Machinery, Ltd. 51
Allen, A. H., & Co. (Engineers), Ltd. 69
Allott Bros. & Leigh, Ltd. 95
Aluminium Wire & Cable Co., Ltd. 43
Anderton, W. R., & Co., Ltd.... 87
Anderton Springs, Ltd. 48
Arden Products (Kenilworth), Ltd 34
Arkinstall Bros., Ltd. 88
Associated Lead Manufacturers, Ltd. 73
Autoset (Production), Ltd. 76

B.R.C. Engineering Co., Ltd. ..... Cover iii
B.T.R. Industries, Ltd. 101
BX Plastics, Ltd. 47
Baldwin Instrument Co., Ltd... 66
Barns, W., & Son (Holloway), Ltd 119
Bates Bros. (Engineers), Ltd.... 9
Birfield Industries, Ltd. 104
Birlec, Ltd 87
Birmingham Aluminium Casting (1903) Co., Ltd. 108
Booth, J., & Bros. 124
Borg-Warner, Ltd. 38
Bostock & Bramley, Ltd. 21
Boulton & Paul, Ltd. 55
Brackett, F. W., & Co., Ltd. 34
British Ermeto Corp., Ltd. 44
British Quadruplex, Ltd. 32
British Steam Specialties, Ltd... 51
British Thomson-Houston Co. Ltd. 115
Broadfoot, J., & Sons, Ltd. 100
Bronx Engineering Co., Ltd. 52
Broom & Wade, Ltd. 79
Brotherhood, P., Ltd. 130
Brown, D., Corporation (Sales), Ltd. 90
Brown, J., Land Boilers, Ltd... 89
Brown, N. C., Ltd. 33
Brown Lenox & Co. Ltd. 83
Brownlie & Murray, Ltd. 88

PAGE

Brush Electrical Engineering Co., Ltd. 5
Buchanan Bros., Ltd. 101
Budenberg Gauge Co., Ltd.... 118
Bucher, H., & Co. 139

C.A.V., Ltd. 25
C.J.C. Developments (Portsmouth), Ltd. 75
C. & M. Engineering Co., Ltd. 76
Carr, C., Ltd. 21
Carter, B. & F., & Co., Ltd. ... 110
Cascade Water Coolers, Ltd... 128
Charles (Wednesbury), Ltd. 114
Cleveland Bridge & Engineering Co., Ltd. 56
Climax Molybdenum Co. of Europe, Ltd. 64
Clyde Crane & Booth, Ltd. 124
Clyde Crane & Engineering Co. 124
Cohen, G., Sons & Co., Ltd.... 126
Colt Ventilation, Ltd. 2
Coltman, Walter W., & Co. (Boilers), Ltd. 52
Cort, R., & Son, Ltd. 98
Cossentine Bolt & Engineering Co., Ltd. 40
Cox & Danks, Ltd. 40
Crane, Ltd. 96
Craven Bros. (Manchester), Ltd. 66
Crawford Collets, Ltd. 74
Cross Manufacturing Co. (1938), Ltd. 78
Crossley Bros., Ltd. 91
Cuxson, Gerrard & Co., Ltd.... 30

Dawson & Downie, Ltd. 16
Ductile Sheet Stockists, Ltd.... 84

Eclipse Foundry & Engineering Co. (Dudley), Ltd. 59
Edwards, F. J., Ltd. 3
Ekco-Ensign Electric, Ltd. ... 112
Electromagnets, Ltd. 59
Ellison, G., Ltd. 53
Elliston, Evans & Jackson, Ltd. 51
Eltron (London), Ltd. 88
English Electric Co., Ltd. Cover ii
English Universities Press, Ltd. 135
Evans, J., & Sons (Wolverhamton), Ltd. 95

Farmer, L., & Sons. 139
Fel Electric, Ltd. 114
Fenner, J. H., & Co., Ltd. 19

PAGE

Fenter, Ltd. 34
Ferranti, Ltd. 24
Fielding & Platt, Ltd. 65
Filton, Ltd. 76
Firth, T., & Brown, J., Ltd. 45
Firth-Vickers Stainless Steels, Ltd. 46
Fleming & Ferguson, Ltd. 110
Flexello Castors & Wheels, Ltd. 17
Flexible Ducting, Ltd 121
Follsain-Wycliffe Foundries, Ltd. 112
Foord, J., & Co. 139
Ford Motor Co., Ltd. 116
Forster, T. S., & Sons, Ltd. ... 128
Foster Wheeler, Ltd. 17
Fowler, J., & Co. (Leeds), Ltd. 74
Foyles 32
Freer Fans, Ltd. 18
Fuller, Horsey, Sons & Cassell 139

G.W.B. Furnaces, Ltd. 60
Gardiner, Sons & Co., Ltd.... 100
Geipel, W., Ltd. 95
General Electric Co., Ltd. 95
General Refractories, Ltd. 59
Gibbons Bros., Ltd. 109
Goodyear Tyre & Rubber Co. (Gt. Britain), Ltd. 72
Govan Shafting & Engineering Co. 18
Greening, N., & Sons, Ltd. 48
Greenwood & Batley, Ltd. 39
Gresham Transformers, Ltd. 77
Grover & Co., Ltd. 31
Guest, Keen & Nettlefolds (Midlands), Ltd. 102

Hall, J. & E., Ltd. 129
Harboro' Rubber Co., Ltd. 40
Harland Engineering Co., Ltd. 131
Harper, J., & Co., Ltd. 18
Hartridge, L., Ltd. 56
Harvey, G. A., & Co. (London), Ltd. 85
Hermetic Rubber Co., Ltd. 15
Hick Hargreaves & Co., Ltd.... 69
Higgs Motors, Ltd. 37
High Duty Alloys, Ltd. 13
Hilton, R. B., Ltd. 20
Holbrook 16
Hopkinsons, Ltd. 109
Horne, W. D., & Co., Ltd. 17
Hudson, R., Ltd. 71
Humphreys & Glasgow, Ltd.... 54
Huntingdon Rubber Co., Ltd. 97

PAGE

ITD, Ltd. 8
Imperial Chemical Industries, Ltd. 12–92
Ince Forge Co. 76
International Combustion, Ltd. 99
International Combustion Products, Ltd. 103
International Harvester Co. of Great Britain, Ltd. 140
Ironmonger. 28
Isler, C., & Co., Ltd. 113

Kay, S., Rubber Co., Ltd. 30
Kay & Co. (Engineers), Ltd. ... 78
Kearns, H. W., & Co., Ltd. 22
Keith Blackman, Ltd. 117
Kelvin & Hughes (Industrial), Ltd. 127
Kier, J. L., & Co., Ltd. 62
Kirk & Co. (Tubes), Ltd. 100
Kosine, Ltd. 69
Kubach, F. W., Ltd. 95

Lang Pneumatic, Ltd. 49
Lincoln Electric Co., Ltd. 123
Lloyd, F. H., & Co., Ltd. 57
Lockwood & Carlisle, Ltd. 110
Lodge-Cottrell, Ltd. 72

MacLellan, P. & W., Ltd. 110
Mann Egerton & Co., Ltd. 32
Marsden, S., & Son, Ltd. 18
Marshall & Anderson, Ltd. 107
Marshall Fleming & Co., Ltd. 78
Mather & Platt, Ltd. 84
Mechanical Handling Exhibition 6
Metaducts, Ltd. 142
Metropolitan - Vickers Electrical Co., Ltd. 58
Midgley & Sutcliffe, Ltd. 96
Millers Rings, Ltd. 88
Minnesota Mining & Manufacturing Co., Ltd. 68
Mitchell, L. A., Ltd. 51
Mitchells, Ashworth, Stansfield & Co., Ltd. 4
Modern Wheel Drive, Ltd. 112
Monochrome, Ltd. 39
Morris, H., Ltd. 111
Moss Gear Co., Ltd. ... Cover iv
Murex Welding Processes, Ltd. 61
Musgrave & Co., Ltd. 80

National Plastics (Sales), Ltd. 75

PAGE

Neco Geared Motors, Ltd. 56
Newall Group Sales, Ltd. 125
Newalls Insulation Co., Ltd.... 70
Newbury Diesel Co., Ltd. 95

Opperman, S. E., Ltd. 78
Osborn, S., & Co., Ltd. 82

Palnut Co., Ltd. 28
Parker, F., Ltd. 52
Parsons Chain Co., Ltd. 106
Pegler & Louden, Ltd. 67
Pinchin, Johnson & Co. 31
Pioneer Oilsealing & Moulding Co., Ltd. 70
Pitman, Sir Isaac, & Sons, Ltd. 135
Plenty & Son, Ltd. 121
Pontifex, H., & Sons, Ltd. 113
Pool, J. & F., Ltd. 56
Potter, F. W., & Soar, Ltd. 88
Power-Gas Corporation, Ltd. .. 11
Priest Furnaces, Ltd. 59
Pulsometer Engineering Co., Ltd. 35
Pulverizing Machinery, Ltd.... 29

Quasi-Arc, Ltd. 105

Ransomes, Sims & Jefferies, Ltd. 67
Richardsons Westgarth (Hartlepool), Ltd. 10
Ross, D., & Partners, Ltd. 30
Rowlinson-Broughton 15
Rubber Improvement, Ltd. 63
Ruberoid Co., Ltd. 94
Ruston & Hornsby, Ltd. 62

S.G.B. 40
Salter, G., & Co., Ltd. 14
Savery, T., Pumps, Ltd. 86
Schieldrop & Co., Ltd. 23
Scriven Machine Tools, Ltd. ... 40
Sharp Control Gear, Ltd. 31
Shawe Metal Spinning Works 48
Sheepbridge Equipment, Ltd... 67
Sheet Metal Shapes, Ltd. 76
Sierex, Ltd. 43
Small & Parkes, Ltd. 32
Smedley Bros., Ltd. 76
Smith, H., & Co. (Possil), Ltd. 36
Smith, J. W. (Coventry), Ltd.... 18
Smith, S., & Sons (England), Ltd. 93
Smith, T., & Sons (Rodley), Ltd. 26

PAGE

Smith & McLean, Ltd. 114
Somers, W., Ltd. 81
Spirax-Sarco, Ltd. 35
Steam Storage Co., Ltd. 34
Sturtevant Engineering Co., Ltd. 4
Sugden, T., Ltd. 86

Tangyes, Ltd. 27
Taylor, F., & Sons (Manchester), Ltd. 35
Taylor Industrial Clutches..... 30
Taylor Woodrow 7
Teddington Aircraft Controls, Ltd. 116
Telco, Ltd. 101
Thompson Bros. (Bilston), Ltd. 15
Thorn, J., & Sons, Ltd. 29
Thornton, B., Ltd. 130
Thornycroft, J. I., & Co., Ltd. 98
Tilghman's, Ltd. 42
Torrington Co., Ltd. 122
Tyseley Foundry, Ltd. 36

United Coke & Chemicals Co., Ltd. 49
United Filters & Engineering, Ltd. 118
United Steel Companies, Ltd.... 49

Vacu-Blast, Ltd. 55
Varatio-Strateline Gears, Ltd. 24
Vokes Genspring, Ltd. 120

Ward, T. W., Ltd. 76–139
Wareing Bros. & Co., Ltd. 33
Wellington Tube Works, Ltd... 118
Wellman Bibby Co., Ltd. 86
Wells, A. C., & Co., Ltd. 29
West Ham Testing Laboratory 82
West's Piling & Construction Co., Ltd. ..... Cover i
Westwood, J., & Co., Ltd. 128
Wheatley Kirk, Price & Co. 139
Widnes Foundry & Engineering Co., Ltd 50
Wilkinson Rubber Linatex Ltd. 119
Williams, J., & Sons (Cardiff), Ltd. 74
Wiseman, A., & Co., Ltd. 60

Yarrow & Co., Ltd. 97
Yorkshire Imperial Metals, Ltd. 3
Youngs (Lifting Appliances), Ltd. 97

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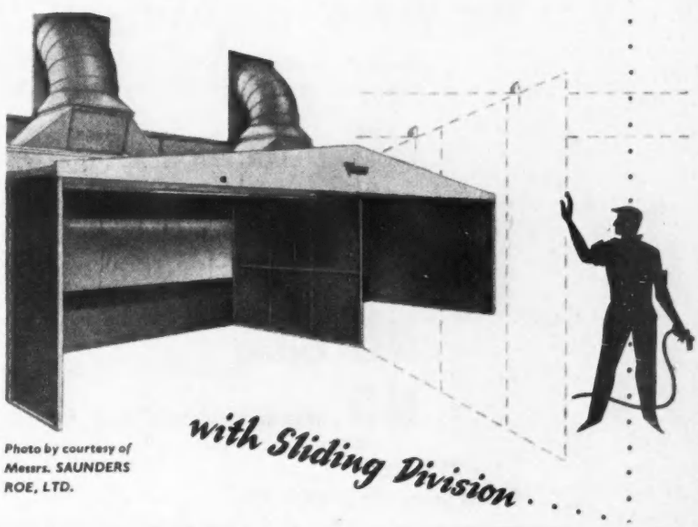

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P.359

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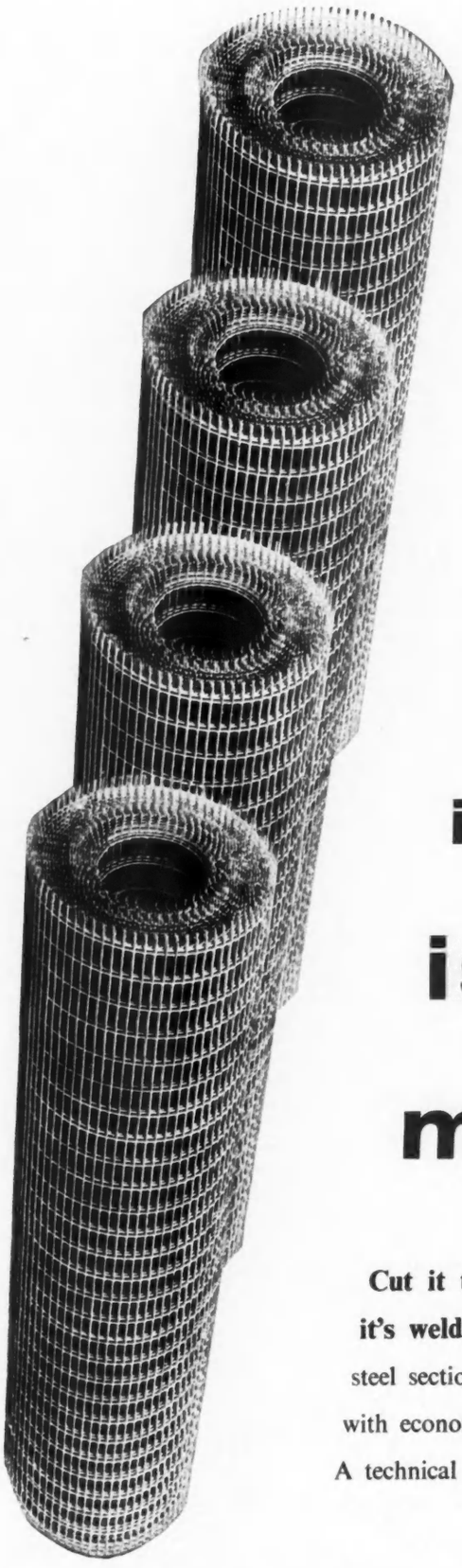

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